TEXAS
WATER
DEVELOPMENT
BOARD

Report 169

GROUND-WATER RESOURCES OF RAINS AND VAN ZANDT COUNTIES, TEXAS

April 1973

TEXAS WATER DEVELOPMENT BOARD

REPORT 169

GROUND-WATER RESOURCES OF RAINS AND VAN ZANDT COUNTIES, TEXAS

By

D. E. White
United States Geological Survey

This report was prepared by the U.S. Geological Survey
under cooperative agreement with the
Texas Water Development Board

April 1973

TEXAS WATER DEVELOPMENT BOARD

John H. McCoy, Chairman
Robert B. Gilmore
Milton T. Potts

Marvin Shurbet, Vice Chairman
W. E. Tinsley
Carl Illig

Harry P. Burleigh, Executive Director

Authorization for use or reproduction of any original material *contained in this publication, i.e., not obtained from other sources, is freely granted. The Board would appreciate acknowledgement.*

Published and distributed
by the
Texas Water Development Board
Post Office Box 13087
Austin, Texas 78711

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd.)

TABLES

FIGURES

TABLE OF CONTENTS (Cont'd.)

TABLE OF CONTENTS (Cont'd.)

GROUND-WATER RESOURCES OF RAINS AND VAN ZANDT COUNTIES, TEXAS

BY

D. E. White
United States Geological Survey

ABSTRACT

Rains and Van Zandt Counties in northeast Texas have abundant water resources and comparatively little water demand. The water is derived from the heavy precipitation (about 43 inches annually), which fills the numerous lakes and reservoirs, and recharges the fresh-water aquifers.

One of the aquifers in the area, the Carrizo-Wilcox, has been appreciably developed. During 1969, this aquifer supplied a reported 1,500 acre-feet of water for municipal supply, industrial use, and rural water systems in the two counties.

The Carrizo-Wilcox aquifer contains an estimated 50 million acre-feet of fresh to slightly saline water in storage. About 10 percent of this amount, or 5 million acre-feet, is thought to be available to wells. In addition to the water in storage, the Carrizo-Wilcox aquifer annually receives an estimated 5,000 acre-feet of effective recharge from precipitation.

Yields of wells tapping the Carrizo-Wilcox aquifer are reported to range from less than 5 to as much as 600 gpm (gallons per minute). Most of the municipal and industrial wells are equipped to pump at rates of 100 to 250 gpm. Yields exceeding 250 gpm normally cannot be sustained during extended periods of pumping.

A second aquifer, the Queen City Sand, in southeastern Van Zandt County, which is currently tapped solely for rural domestic and livestock supply, probably is capable of yielding as much as 150 gpm of fresh water to properly constructed wells.

GROUND-WATER RESOURCES OF RAINS AND VAN ZANDT COUNTIES, TEXAS

INTRODUCTION

Purpose and Scope of the Investigation

The ground-water studies in Rains and Van Zandt Counties began in the spring of 1969, as a cooperative project of the U.S. Geological Survey and the Texas Water Development Board. The purpose of the investigation was to determine and evaluate the ground-water resources of the two counties. The investigation encompassed the collection, compilation, and analysis of data related to ground water. The location and extent of the water-bearing formations, their hydraulic properties, and the chemical quality of the water, were determined. The quantity of ground water withdrawn was estimated and the effects of these withdrawals on the water level were evaluated. The quantity of ground water available was estimated. The results of the investigation, as presented in this report, include an analytical discussion of the occurrence and availability of the ground-water supplies, together with a tabulation of basic data obtained during this and previous investigations.

Location and Extent of the Area

Rains and Van Zandt Counties are in northeast Texas (Figure 1). Rains County is bordered by Hunt County on the north and west, Hopkins County on the north and east, Wood County on the east, and Van Zandt County on the south. Van Zandt County is bordered by Hunt, Rains, and Wood Counties on the north, Kaufman County on the west, Henderson County on the south, and Smith County on the east. Canton, the Van Zandt County seat, is 73 miles east-southeast of Dallas, and 37 miles west-northwest of Tyler. Emory, the Rains County seat, is 23 miles north of Canton. The report area includes 1,090 square miles; 235 square miles in Rains County and 855 square miles in Van Zandt County.

Methods of Investigation

The following methods were used during the investigation:

1. All moderate- to large-capacity wells and a representative number of small-capacity wells (a total of 308 wells) were inventoried. Records of wells are given in Table 4; locations of wells are shown on Figure 26.

2. Electrical and drillers' logs were collected for correlation and evaluation of subsurface characteristics of the aquifers. A map was prepared showing the depth to and the altitude of the top of the Midway Group (Figure 9). Subsurface correlation of the geologic units are shown on Figures 7 and 8.

3. The quantities of ground and surface water used for municipal, rural, and industrial supply were inventoried (Table 2, Figure 19).

4. The results of 10 aquifer tests (Figures 11-18) were used to determine the hydraulic characteristics of the principal aquifer.

5. Water levels were measured, and available records of past fluctuations of water levels were compiled (Table 4; Figures 20 and 21).

6. Climatological records were collected (Figures 2 and 3).

7. Chemical analyses of water samples collected from wells, streams, and lakes during this and previous investigations (a total of 337 analyses) were compiled (Tables 5 and 6).

8. A map showing the specific conductance, hardness, and the concentration of sulfate and chloride in water from wells and a graph showing the relation of dissolved solids to specific conductance of water were prepared (Figure 22).

9. The hydrologic data were analyzed to determine the quantity and quality of ground water available for development. A map was prepared to show the areas most favorable for future development (Figure 25).

Previous Investigations

The geologic formations in Rains and Van Zandt Counties were described by Sellards and others (1932).

Broadhurst (1943) compiled records of 57 wells and one spring in Rains County and tabulated eight drillers' logs and 45 chemical analyses of water from wells. Sundstrom and others (1948) compiled data regarding the public water supplies of Canton, Edgewood, Grand Saline, and Wills Point in Van Zandt County. Baker and others (1963) briefly described the aquifers in Rains and Van Zandt Counties as part of a reconnaissance of the ground-water resources of the Sabine River Basin.

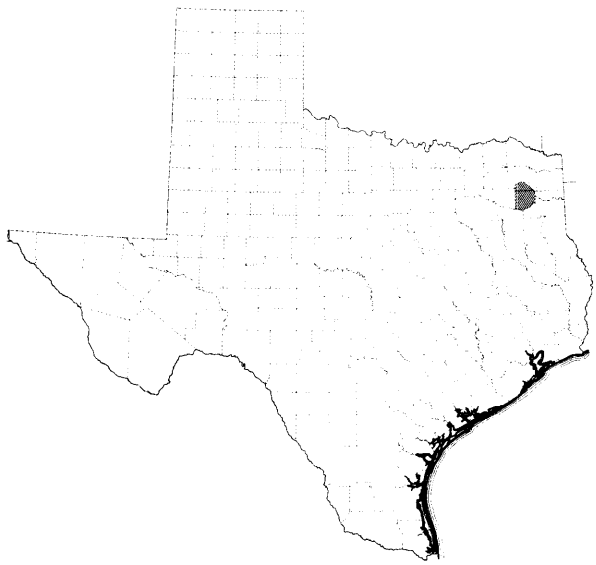


Figure 1.—Location of Rains and Van Zandt Counties

Detailed ground-water investigations have been made in two counties adjacent to the report area—Wood County (Broom, 1968) and Smith County (Dillard, 1963).

Hughes and Leifeste (1965 and 1967) described the quality of surface waters in the Sabine and Neches River Basins. The U.S. Geological Survey, in cooperation with the Texas Water Development Board and other Federal and local agencies, is currently (1969) maintaining two quality-of-water, one reservoir-stage, and two streamflow stations in the report area.

Climate

The climate in Rains and Van Zandt Counties is characterized by heavy rainfall and high humidity, particularly during the spring; by moderately high temperatures during the summer; and by relatively mild winters.

The records of the National Weather Service (formerly, the U.S. Weather Bureau) for Wills Point in northeastern Van Zandt County provide the most complete climatological data for the report area. The annual precipitation at Wills Point for the period 1905-69 is shown on Figure 2. The records are incomplete or missing for the period 1922-39. During the 47 years of complete records, precipitation ranged from a maximum of 64.93 inches in 1905, to a minimum of 24.96 inches in 1910; the annual average was 44.39 inches. The average annual rainfall for the 30 years of continuous record beginning in 1940 was 43.16 inches. During 1969, when field studies for this investigation were being carried out, precipitation was 43.74 inches, which is about normal.

Generally, April is the wettest month, with an average precipitation of 5.86 inches, and August is the driest month, with an average precipitation of 2.16 inches (Figure 3). The highest monthly precipitation recorded at Wills Point was 21.90 inches in April 1966.

The average monthly temperature at Wills Point ranges from 45°F (7°C) in January to 85°F (29°C) in July and August (Figure 3). The recorded extremes are -1°F (-18°C) and 115°F (46°C). The growing season is about 250 days. The approximate dates for the first and last killing frosts are November 21 and March 16, respectively.

The average annual gross lake-surface evaporation for the area is approximately 49 inches (Kane, 1967). This exceeds the 1940-69 average rainfall at Wills Point by about 6 inches. Evaporation rates are highest during the summer months when precipitation is lowest and the soil-moisture demand of plants is greatest.

Physiography and Drainage

Rains and Van Zandt Counties are in the West Gulf Coastal Plain of east Texas (Fenneman, 1938). The land surface is generally flat along the flood plains of the major streams, but is gently rolling in most other parts of the two counties. The minimum altitude at the confluence of Grand Saline Creek and the Sabine River in the northeast corner of Van Zandt County is about 320 feet above mean sea level. The maximum altitude, about 3 miles south-southwest of Canton, is about 690 feet above mean sea level. The maximum relief is in the southeast corner of Van Zandt County, where six hills capped by the Sparta Sand rise as much as 200 feet above the intervening stream valleys.

All of Rains County is in the drainage basin of the Sabine River (Figure 26). The northeastern part of the county is drained by Lake Fork Creek, which flows southeastward through Rains and Wood Counties. The remainder of the county is drained by eight small creeks that flow directly into the Sabine River or into Lake Tawakoni.

Van Zandt County is in the drainage basins of the Trinity, Sabine, and Neches Rivers. The northern half of

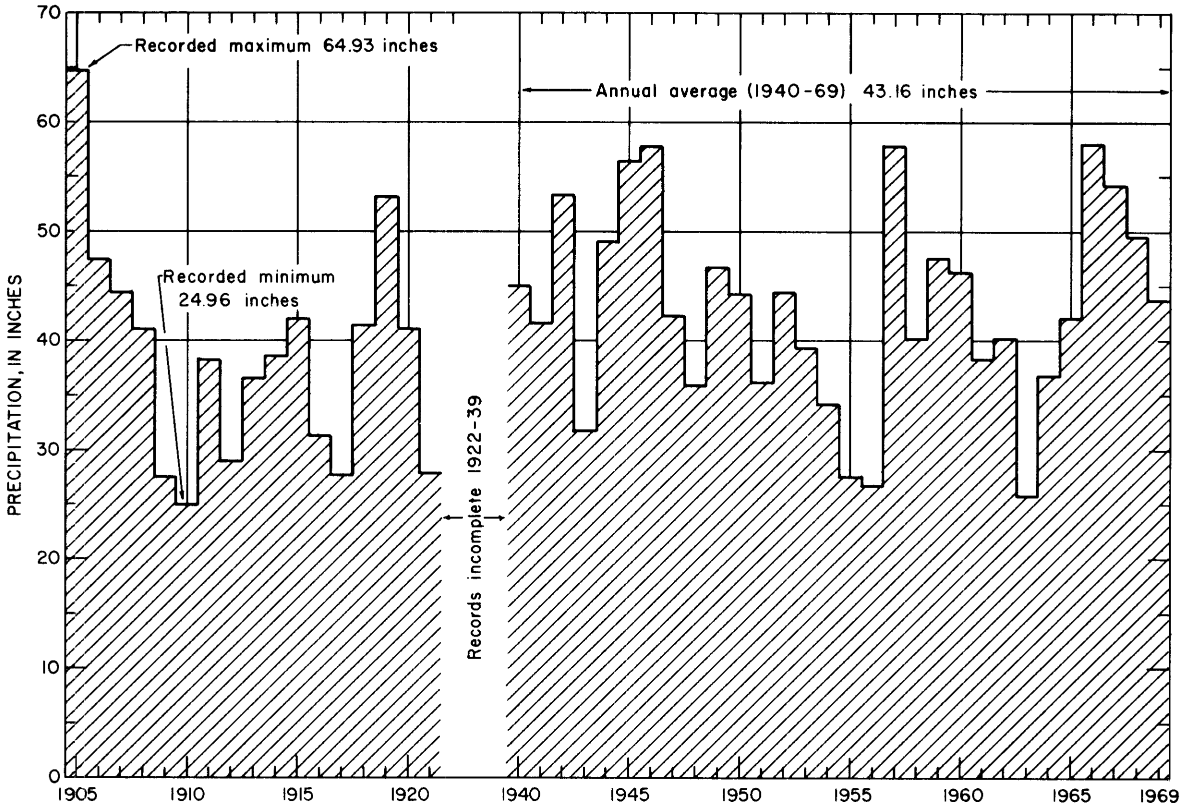


Figure 2.—Annual Precipitation at Wills Point, 1905-69

the county is drained by the Sabine River; its principal tributaries are McBee, Mill, Caney, Grand Saline, and Village Creeks.

An area of 222 square miles in west-southwestern Van Zandt County is drained by tributaries of the Trinity River; Cedar, Allen, Caney, Twin, and Purtis Creeks and Lacy Fork. Cedar Creek, which has a drainage area of 93 square miles within the county, is the principal tributary.

The Neches River drains 242 square miles in the southeastern quarter of Van Zandt County. The river originates near the community of Colfax, 8 miles east-southeast of Canton. The principal tributaries of the Neches River are Browning, Horsley, Kickapoo, Alligator, Cream, Slater, and Murchison Creeks.

Population and Economy

According to the U.S. Census Bureau, Rains and Van Zandt Counties had populations of 3,752 and 22,155, respectively in 1970. The communities that had a population of 200 or more were: Emory (693) and Point (419), in Rains County; Wills Point (2,636), Edgewood (1,176), Grand Saline (2,257), Canton (2,283), Van (1,593), Edom (201), and Fruitvale (206) in Van Zandt County. The State and county populations for the census years 1850-1970 are shown on Figure 4.

The population trends shown on Figure 4 reflect a pronounced change in the area's economy. The peak in the population was reached in the 1920's and 30's. Until that time, the production of cotton was the chief industry; since the 1930's, the cotton acreage has sharply declined and has been replaced by a flourishing cattle industry, which requires a much smaller labor force.

Oil was discovered in Van Zandt County in 1929 (Van Field). As of January 1, 1968, slightly over 2 million barrels of crude oil had been produced in the county (Railroad Commission of Texas, 1968). Of this amount, 1,378,823 barrels were produced in the Van Field. The production of oil, gas, and hydrocarbon liquids in the report area during 1967 was as follows:

	VAN ZANDT COUNTY	RAINS COUNTY
Oil (barrels)	108,899	0
Gas (million cubic feet)	18,882	4,296
Hydrocarbon liquids (barrels)	3,685	0

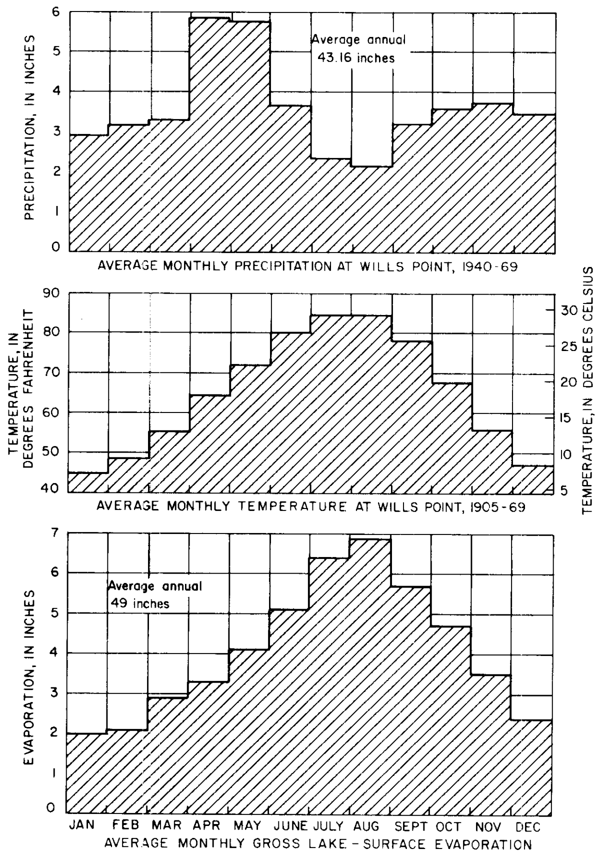


Figure 3.—Average Monthly Precipitation and Temperature at Wills Point and Average Monthly Gross Lake-Surface Evaporation

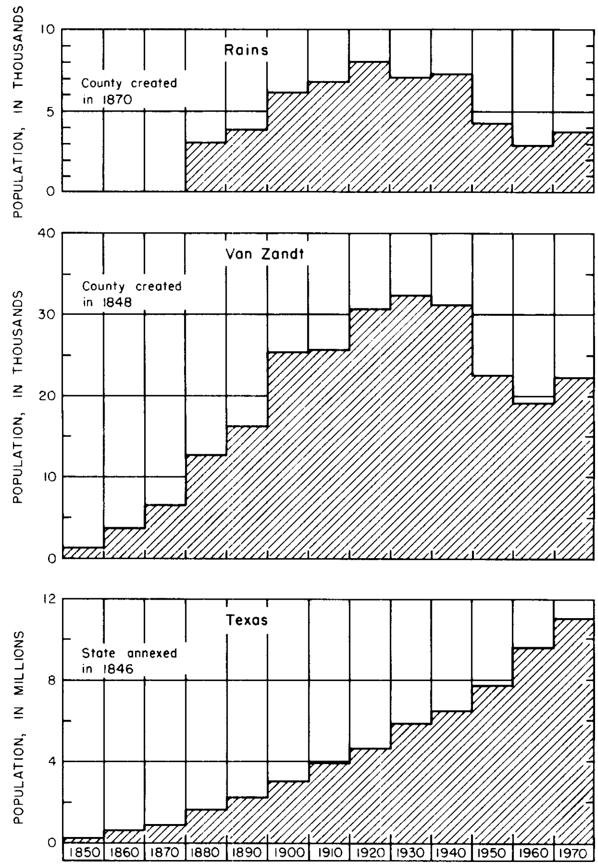


Figure 4.—Populations of Rains and Van Zandt Counties and the State of Texas, 1850-1970

In 1929, the Morton Salt Company excavated a 700-foot shaft into the Grand Saline Dome in Van Zandt County and began mining salt by the room and pillar method. Currently (1969), an estimated 270,000 tons of salt are being mined annually at Grand Saline.

Well-Numbering System

The well-numbering system used in this report was adopted by the Texas Water Development Board for use throughout the State (Figure 5). Under this system, each 1-degree quadrangle in the State is given a number consisting of two digits; Rains and Van Zandt Counties include parts of quadrangles 33 and 34. These are the first two digits in the well number. Each 1-degree quadrangle is divided into 7½-minute quadrangles which are given 2-digit numbers from 01 to 64. These are the third and fourth digits of the well number. Each 7½-minute quadrangle is subdivided into 2½-minute quadrangles given a single digit number from 1 to 9. This is the fifth digit of the well number. Finally, each well within a 2½-minute quadrangle is given a 2-digit number in the order in which it was inventoried, starting with 01. These are the last two digits of the well number. In addition to the seven-digit number, a two-letter prefix is used to designate the county.

The prefixes for Rains, Van Zandt, and adjacent counties are as follows:

COUNTY	PREFIX
Henderson	LT
Rains	UX
Smith	XH
Van Zandt	YS
Wood	ZS

Thus, well YS-34-19-407 which is owned by the city of Grand Saline, is in Van Zandt County (YS), in the 1-degree quadrangle 34, in the 7½-minute quadrangle 19, in the 2½-minute quadrangle 4, and was the seventh well (07) inventoried in that 2½-minute quadrangle (Figure 5).

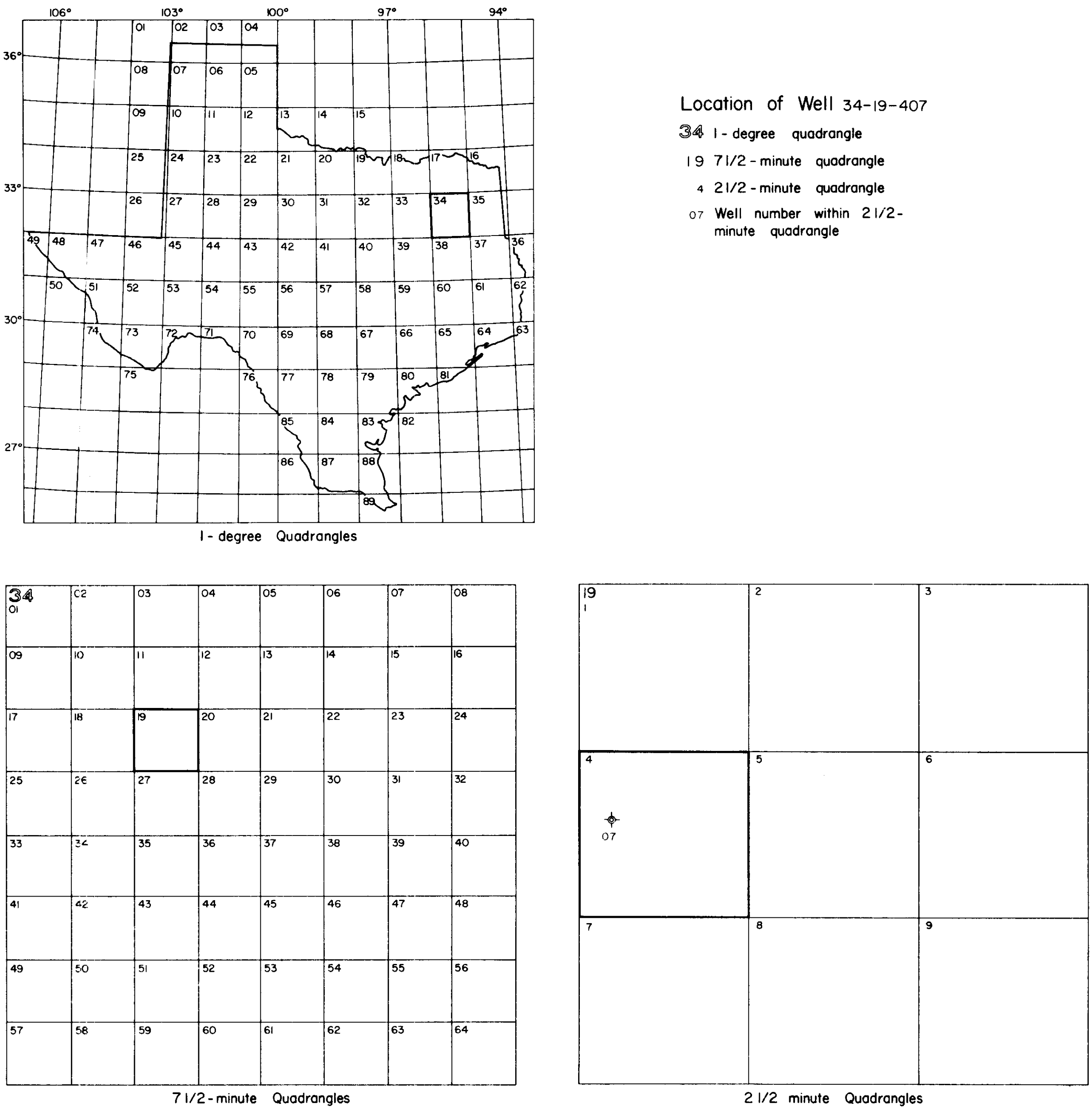


Figure 5
Well-Numbering System

Acknowledgments

This investigation was completed largely through the cooperation of well owners and county, city, and industrial officials, who allowed access to their property and permitted the examination of pertinent records. Most of the aquifer-test data shown on Figures 11 through 18 were obtained from the files of William F. Guyton and Associates, Consulting Hydrologists, Austin, Texas; the Layne-Texas Company, Dallas, Texas; and Edington Drilling Company, Shreveport, Louisiana. A considerable amount of information about ground-water conditions in the vicinity of Grand Saline was furnished by the Morton Salt Company. The Farmers Home Administration at Canton supplied data about the rural water systems in Van Zandt County.

GEOLOGY AS RELATED TO THE OCCURRENCE OF GROUND WATER

General Stratigraphy and Structure

Geologic units of Eocene age are the principal sources of ground water in Rains and Van Zandt Counties. The thickness, lithology, and water-bearing properties of these units are discussed in the following section and are summarized in Table 1. The areal extent (outcrops) of the formations are shown on Figure 6; the subsurface relationships of the geologic units are shown on Figures 7 and 8.

In general, the units crop out in belts that trend northeastward; however, in the vicinity of Van, upward movement of the rocks and subsequent erosion has caused the outcrops to be offset about 5 miles southeast of the regional trend.

The contacts between the geologic units above the Midway Group often are difficult to determine from drillers' and electrical logs; consequently, the contacts shown on Figure 8 and the thicknesses of the units shown on Table 1 are only approximate. The top of the Midway Group is the approximate base of fresh to slightly saline water in the report area. The altitude of and depth to the top of the Midway are shown on Figure 9. The Wilcox Group, which is the lowermost unit containing fresh water, contains nearly all of the water-bearing sands.

The Claiborne Group, which overlies the Wilcox Group, includes in ascending order, Carrizo Sand, Reklaw Formation, Queen City Sand, Weches Greensand, and Sparta Sand.

The general southeast dip of the geologic units result from structural down-warping of the East Texas embayment. The embayment is the troughlike geologic basin in which the long axis trends northeastward through the counties east of the report area.

The faults and folds in the area account for the entrapment of abundant quantities of oil and gas. The amount of displacement along the faults and the steepness of the folds generally decrease upward. Few of the faults extend upward to the water-bearing units, but locally, the folds are reflected at the surface, as on the flanks of the Van Dome.

Physical Characteristics and Water-Bearing Properties of the Geologic Units

In the description of the water-bearing properties of the geologic units, the yields of wells are described according to the following rating:

DESCRIPTION	YIELD (GALLONS PER MINUTE)
Small	Less than 50
Moderate	50 to 500
Large	More than 500

In general, the chemical quality of the water is classified as follows:

DESCRIPTION	DISSOLVED-SOLIDS CONTENT (MILLIGRAMS PER LITER)
Fresh	Less than 1,000
Slightly saline	1,000 to 3,000
Moderately saline	3,000 to 10,000
Very saline	10,000 to 35,000
Brine	More than 35,000

Midway Group

The Midway Group crops out in western Rains and Van Zandt Counties (Figure 6). The top of the Midway dips southeastward at rates of about 40 to 45 feet per mile (Figures 7 and 8), and reaches a depth of more than 1,500 feet below the land surface in southeastern Van Zandt County.

Primarily marine in origin, the Midway Group consists largely of calcareous clay; but locally the formation contains thin stringers of limestone and glauconitic sand. At the outcrop, the Midway weathers to grayish-brown or gray sandy loam and clay loam soils. The soil and plastic clay subsoil have very low permeabilities. Consequently, most of the rainfall either runs off or collects in surface depressions where it evaporates or transpires.

During this investigation, 16 wells tapping the Midway Group were inventoried. All of the wells were on the outcrop of the Midway. Six of the wells were not

Table 1.--Geologic and Hydrologic Units and Their Water-Bearing Properties

SYSTEM	SERIES	GROUP	GEOLOGIC UNIT	APPROXIMATE MAXIMUM THICKNESS (FT)	CHARACTER OF SEDIMENTS	WATER-BEARING PROPERTIES
Quaternary	Holocene and Pleistocene		Alluvium	50	Sand, silt, clay and minor amounts of gravel	Not known to yield water to wells in the report area. The thicker deposits would probably yield small to moderate quantities of water.
Tertiary	Eocene	Claiborne	Sparta Sand	50	Sand and clay	Cap hills in southeastern Van Zandt County. Not known to yield water to wells in the report area.
			Weches Greensand	60	Glauconite, glauconitic clay and sand	Not known to yield water to wells in the report area.
			Queen City Sand	400	Sand, silt, and clay with stringers of lignite and bentonitic clay	Yields small quantities of fresh water to domestic and stock wells in southeastern Van Zandt County.
			Reklaw Formation: Marquez Shale Member of Stenzel (1938)	40 70	Silty shale	Not known to yield water to wells in the report area.
			Reklaw Formation: Newby Sand Member of Stenzel (1938)	30	Glauconitic sand	Yields small quantities of fresh water to large - diameter wells on the outcrop. Wells tapping the Newby and Carrizo Sand in southeastern Van Zandt County yield moderate quantities.
			Carrizo Sand	150	Sand and minor amount of silt and clay	Yields small to moderate quantities of fresh water to wells in southeastern Van Zandt County.
		Wilcox		960	Lenticular beds of sand, with sandy clay, shale, sandstone and lignite	Yields small to moderate quantities of water to wells in Rains and Van Zandt Counties. Large quantities have been pumped during aquifer tests in a few wells near Grand Saline.
	Paleocene	Midway		Not measured	Calcareous clay with stringers of limestone and glauconitic sand	Yields very small quantities of water to a few wells in western Rains and Van Zandt Counties.

in use or had been abandoned, the rest had very small yields and would be called "dry holes" by most drillers. Although the Midway Group does not yield appreciable quantities of water to wells in the report area, it is hydrologically significant downdip from its outcrop where it forms a basal confining layer for water stored in the overlying Wilcox Group.

Wilcox Group

The Wilcox Group, the principal source of ground water in Rains and Van Zandt Counties, crops out diagonally across southwestern, central, and northeastern Van Zandt County and eastern Rains County. The outcrop in Van Zandt County ranges from about 7 miles to about 22 miles in width (Figure 6).

The Wilcox Group has a maximum thickness of about 960 feet in southeastern Van Zandt County. Lithologically, the unit is a heterogeneous accumulation of sandy clay and shale; crossbedded, micaceous, ferruginous sandstone; lignitic shale, and lignite. Medium to very fine quartz sand constitutes about half of the Wilcox. Individual layers of sand are generally thin-bedded, although some beds have a thickness of as much as 70 feet (Figure 17). The layers of sand are lenticular; few, if any, can be correlated for any significant distance.

At the outcrop, the Wilcox weathers to slightly undulating or hilly terrain that is well drained. The soils are dominantly grayish-brown, sandy loam near the surface, and mottled red, yellow and gray acidic clay or sandy clay 6 to 12 inches below the surface. The Wilcox soils are generally lighter textured and more permeable than soils on the Midway outcrop.

In general, wells tapping the Wilcox near its up-dip limit yield 25 gpm (gallons per minute) or less. Yields exceeding 500 gpm have been obtained from wells that screen most of the water-bearing sands in and near the city of Grand Saline (Figures 14 and 17). However, these yields were obtained during short-term aquifer tests. In most wells, yields exceeding 250 gpm cannot be sustained without lowering the water level below the casing perforations, thereby creating turbulence and decreasing purnp efficiency. With only a few exceptions, all wells tapping the Wilcox in the report area pump fresh water (Figure 22, Table 5). However, the chemical composition and physical properties of the water are variable, and some water is not suitable for its present use. (See section entitled, "Quality of Water".)

Claiborne Group

Carrizo Sand

The Carrizo Sand, the lowermost unit in the Claiborne Group, crops out in an irregular and discontinuous band that trends diagonally across the southeastern part of Van Zandt County (Figure 6). Because of irregularities in the depositional surface and because of post-depositional upwarping and faulting, the thickness of the Carrizo and the width of the outcrop are variable. The maximums are about 150 feet and 2.5 miles, respectively.

The Carrizo consists largely of white to gray, fine to medium quartz sand. However, minor amounts of silt and clay are present in the upper part of the formation. The Carrizo weathers to a pale or grayish-brown sandy loam soil. Although the soil is easily worked, it does not support a dense growth of vegetation.

The Carrizo yields small to moderate quantities of fresh water to wells in Van Zandt County. In the southeast part of the county, the Carrizo supplies two rural water systems. Well YS-34-36-701, which supplies the Edom system, reportedly had a drawdown of 57 feet while pumping 75 gpm during a 24-hour development test by the driller. This well was screened opposite 40 feet of interbedded sand and shale in the Carrizo. Well YS-34-36-901, which supplies the R.P.M. water system, had a drawdown of 78 feet while pumping 130 gpm for 24 hours. This well was screened opposite 20 feet of massive sand in the Carrizo, and 30 feet of interbedded sand and shale in the Carrizo and overlying Reklaw Formation.

Reklaw Formation

The Reklaw Formation, which is 50 to 70 feet thick, was divided into a lower member (the Newby Sand) and an upper member (the Marquez Shale), by Stenzel (1938) in Leon County. The member names have not been adopted by the U.S. Geological Survey.

The Newby Member is gray to green, fine to very fine glauconitic sand, 20 to 30 feet thick. At the outcrop, the sand weathers to hard, ledge-forming, red sandstone that is easily identified. However, in the subsurface, it cannot be readily distinguished from the sand in the underlying Carrizo.

The Marquez Member is black to chocolate brown, silty, carbonaceous shale, 30 to 40 feet thick. In the subsurface, the shale is easily identified on well logs and is an important marker horizon for drillers. More importantly, the shale provides a persistent hydrologic boundary that prevents or at least retards the vertical movement of water between the overlying Queen City Formation and underlying Newby Sand Member of the Reklaw Formation and the Carrizo Sand.

The Newby Sand Member yields small quantities of fresh water to large-diameter dug or bored wells in the outcrop. The upper part of the Reklaw, the Marquez Shale Member, is not known to yield water.

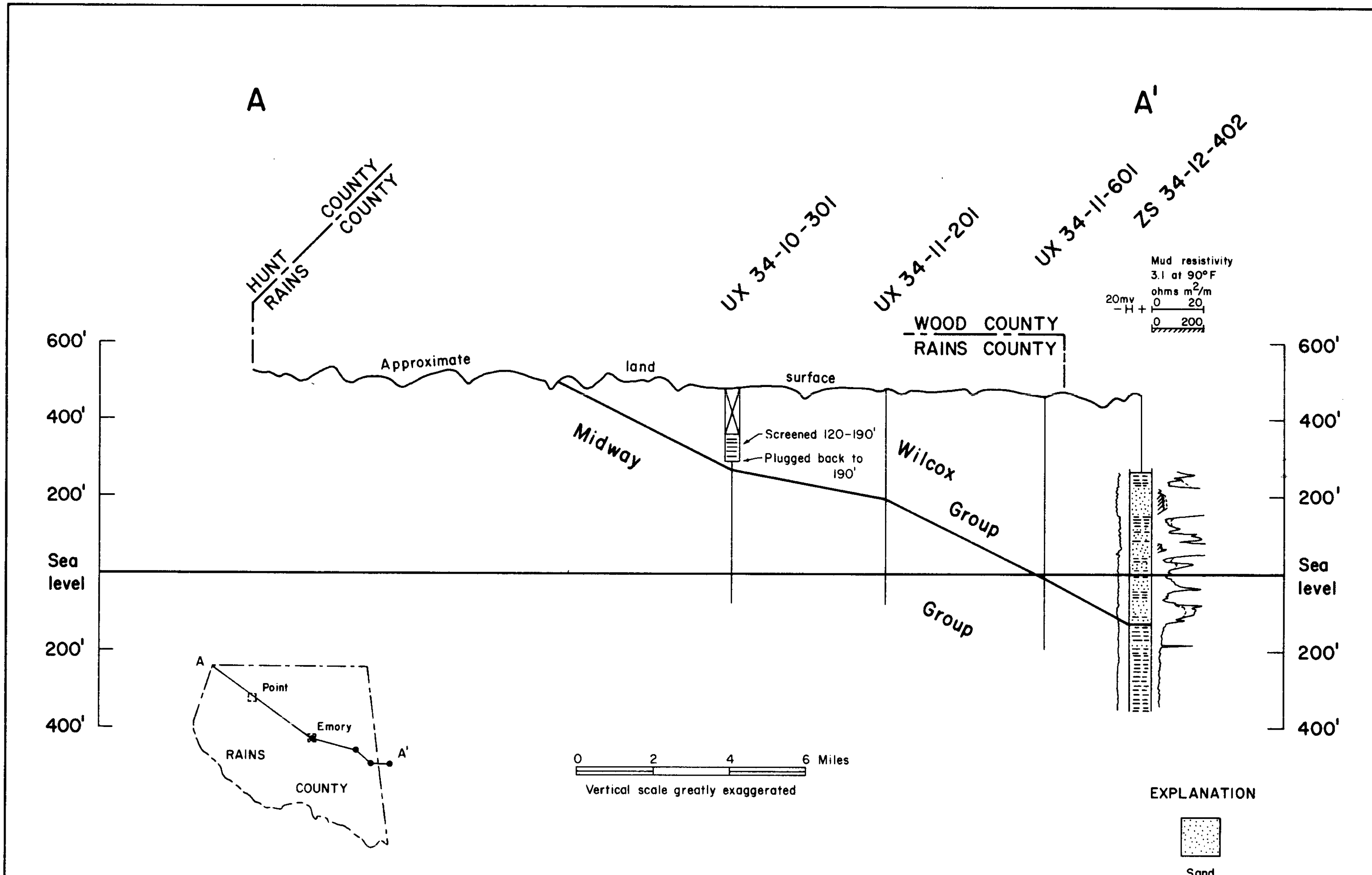


Figure 7
Correlation of Geologic Units
Along Line A-A'

Queen City Sand

The Queen City Sand crops out in southeastern Van Zandt County in moderately rolling to hilly terrain that is well drained. The hills are mantled by grayish-brown, fine sandy-loam soils that are loose and easily tilled. In the subsurface, the Queen City consists mostly of thick-bedded to massive crossbedded sand that is interbedded with silt and clay. Stringers of lignite and bentonitic clay occur in the upper part of the formation. From the edge of the outcrop, the formation dips and thickens southeastward. The maximum thickness, about 400 feet, occurs in the hills near the southeast corner of Van Zandt County (Figure 8).

The Queen City Sand yields small quantities of fresh water to domestic and stock wells at the outcrop. On the basis of the results of aquifer tests in Smith County (Dillard, 1963, p. 25), moderate yields (150 gpm or more) could probably be obtained from properly constructed wells in areas where the thickness of saturated sand is sufficient to allow a water-level drawdown of 100 feet.

Weches Greensand and Sparta Sand

The Weches Greensand and the overlying Sparta Sand crop out as small outliers that cap the hills in southeastern Van Zandt County (Figures 6 and 8). The Weches, which is about 60 feet thick, consists principally of interbedded glauconite, glauconitic clay, and sand; secondary deposits of limonite are common at the outcrop. The Weches weathers to a fertile, but rocky soil that supports a thick growth of grass and pines. The Sparta Sand consists of poorly cemented sandstone and light-colored clay that weathers to a white, sandy soil.

Neither the Sparta Sand nor the Weches Greensand are known to yield water to wells in the report area.

Alluvium

Alluvial deposits underlie the flood plains of the rivers and their principal tributaries. The deposits consist of clay, silt, sand, and minor amounts of gravel. The deposits are thin, normally less than 10 feet thick along the tributaries, but are as much as 50 feet thick along the rivers.

The alluvium is not known to yield water to wells in the report area, but small to moderate quantities of water probably could be obtained from wells tapping the thicker deposits.

Hydrologic Units

An aquifer is a formation, group of formations, or a part of a formation that is capable of yielding usable quantities of water. The formations described in the previous section of this report comprise two aquifers and two confining units.

The principal aquifer in Rains and Van Zandt Counties consists of saturated deposits in the Wilcox Group, Carrizo Sand, and Newby Sand Member of the Reklaw Formation, all of which are hydraulically connected. To facilitate discussion, these deposits will be called the Carrizo-Wilcox aquifer in this report.

Water in the Carrizo-Wilcox aquifer is stored between the Midway Group at the base and the Marquez Shale Member of the Reklaw at the top. Both are persistent and effective hydrologic boundaries within the report area.

The second aquifer in the report area, the Queen City Sand, is absent in Rains County; it is present, but virtually untapped in southeastern Van Zandt County. It is an important source of water in Henderson, Smith, and Wood Counties south and east of the report area.

GROUND-WATER HYDROLOGY

The general principles of ground-water hydrology as applied to the study area are discussed in the following section of this report. For additional information on these and other hydrologic principles, the reader is referred to: Meinzer (1923a, 1923b); Meinzer and others (1942); Todd (1959); Tolman (1937); Wisler and Brater (1959); Leopold and Langbein (1960); and Baldwin and McGuinness (1963).

Hydrologic Cycle

The hydrologic cycle, which is the exchange of water between the earth and the atmosphere, is shown diagrammatically on Figure 10. The processes within the cycle that are effective in Rains and Van Zandt Counties can be summarized as follows: Water vapor in the atmosphere condenses and precipitates to the land surface (43 inches annually as an average, Figure 3). The rain infiltrates the soil and collects in ponds, lakes, and streams. Normally, about 12 inches of precipitation leaves the area as runoff; most of the remaining water, about 30 inches, returns to the atmosphere through evapotranspiration.

An unknown, but probably small percentage of the precipitation percolates downward to the water table, which is normally only a few feet below the land surface. Below the surface, water moves laterally and vertically through the lenses of sand and over or around the layers of shale. Most of the water migrates laterally to topographic lows where it is discharged through seeps and evapotranspiration. Less than 1 inch each year moves downdip to the deeper sands in the aquifers.

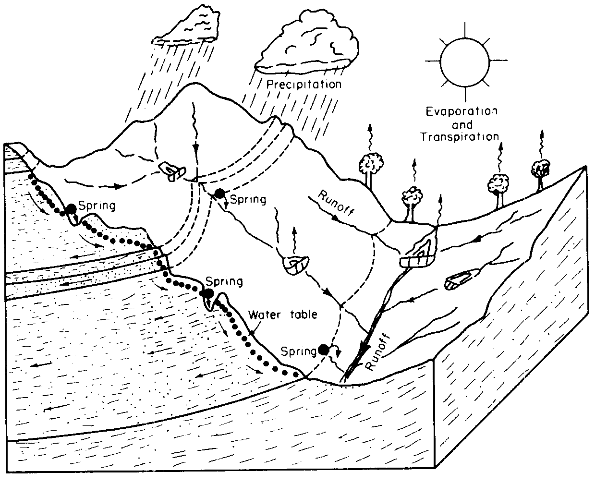


Figure 10.—Generalized Diagram of the Hydrologic Cycle

Hydraulic Properties of the Aquifers

Aquifer tests have been made in a few wells in Rains and Van Zandt Counties to determine the hydraulic conductivity, transmissivity, and coefficient of storage. These properties reflect the capacity of the aquifers to transmit, yield, or store water.

The hydraulic conductivity is the flow of water in cubic feet per day, at the prevailing water temperature, through a cross section of 1 square foot of the aquifer under unit hydraulic gradient. The transmissivity is the rate of flow in cubic feet per day, at the prevailing water temperature, through a vertical strip of aquifer 1 foot wide under unit hydraulic gradient. The hydraulic conductivity and transmissivity can be converted to the units formerly used by the U.S. Geological Survey (coefficients of permeability and transmissibility) by multiplying by the factor 7.48.

The specific capacity of a well, which is the ratio of the discharge to the drawdown or recovery of water levels during a given time interval, provides a general index of the water-yielding capability of an aquifer. Specific capacities are largely dependent upon the hydraulic conductivity of the aquifer; high specific capacities denote high conductivity, and low specific capacities denote low conductivity. However, the specific capacity of a well decreases as the length of pumping time increases. Also, the manner in which a well is completed affects the specific capacity. Other factors being equal, wells that are properly screened to minimize entrance losses have larger specific capacities than those that are improperly completed.

The results of 10 aquifer tests in wells tapping the Wilcox Group are shown on Figures 11 through 18. Eight of the tests were in Van Zandt County; one was in Rains County; and one was in Smith County. The tests shown on Figure 15 were conducted by William F. Guyton and Associates, ground-water consultants in Austin, Texas. The Layne Texas Company in Dallas, Texas, made four tests (Figures 11, 12, 17, and 18); two tests were made by the Edington Drilling Company, Shreveport, Louisiana (Figures 13 and 14); and an additional test was made by the U.S. Geological Survey (Figure 16). The test data were analyzed by one or more of the following methods: The Theis nonequilibrium method (Theis, 1935); the Cooper and Jacob straight-line method of approximation (Cooper and Jacob, 1946); and the Theis recovery method (Wenzel, 1942).

The maximum, minimum, and average transmissivities; hydraulic conductivities; and 24-hour specific capacities were as follows:

TRANSMISSIVITY (T) (FT PER DAY)	HYDRAULIC CONDUCTIVITY (K) (FT PER DAY)	SPECIFIC CAPACITY (GPM PER FT)
1,200	12	4.9
80	1.9	.4
600	6.3	2.4

A storage coefficient for sands in the Wilcox Group was determined by an aquifer test in three wells at Grand Saline. During this test, well YS-34-19-403 was pumped 48 hours at an average rate of 130 gpm. Water levels were measured in the pumped well and in two observation wells, YS-34-19-412 and YS-34-19-407, approximately 1,000 and 3,000 feet respectively from the pumped well. At the end of the 48-hour pumping period, the water levels had declined 118 feet in the pumped well, 6.4 feet in well YS-34-19-412, and 1.7 feet in well YS-34-19-407 (Figure 15).

An average storage coefficient of 0.00038 was calculated from water-level measurements in the two observation wells. This value is within the artesian range, which can be expected in the deeper sands of the Wilcox. Larger storage coefficients would undoubtedly be obtained in tests of the upper sands where water is stored under slight confining pressure.

The results of the aquifer tests in Rains and Van Zandt Counties compare favorably with those obtained by Broom (1968, Table 2) in Wood County where the transmissibilities (transmissivities) of the Carrizo-Wilcox aquifer averaged about 5,700 gpd (gallons per day) per foot (760 ft^2 per day). According to Broom, the average permeability of the aquifer is "on the order of 50 gpd per square foot", or a hydraulic conductivity of 6.7 foot per day.

Little is known about the hydraulic properties of the Queen City aquifer, which is absent in Rains County and is generally untapped in southeastern Van Zandt County. However, in Smith County, Dillard (1963,

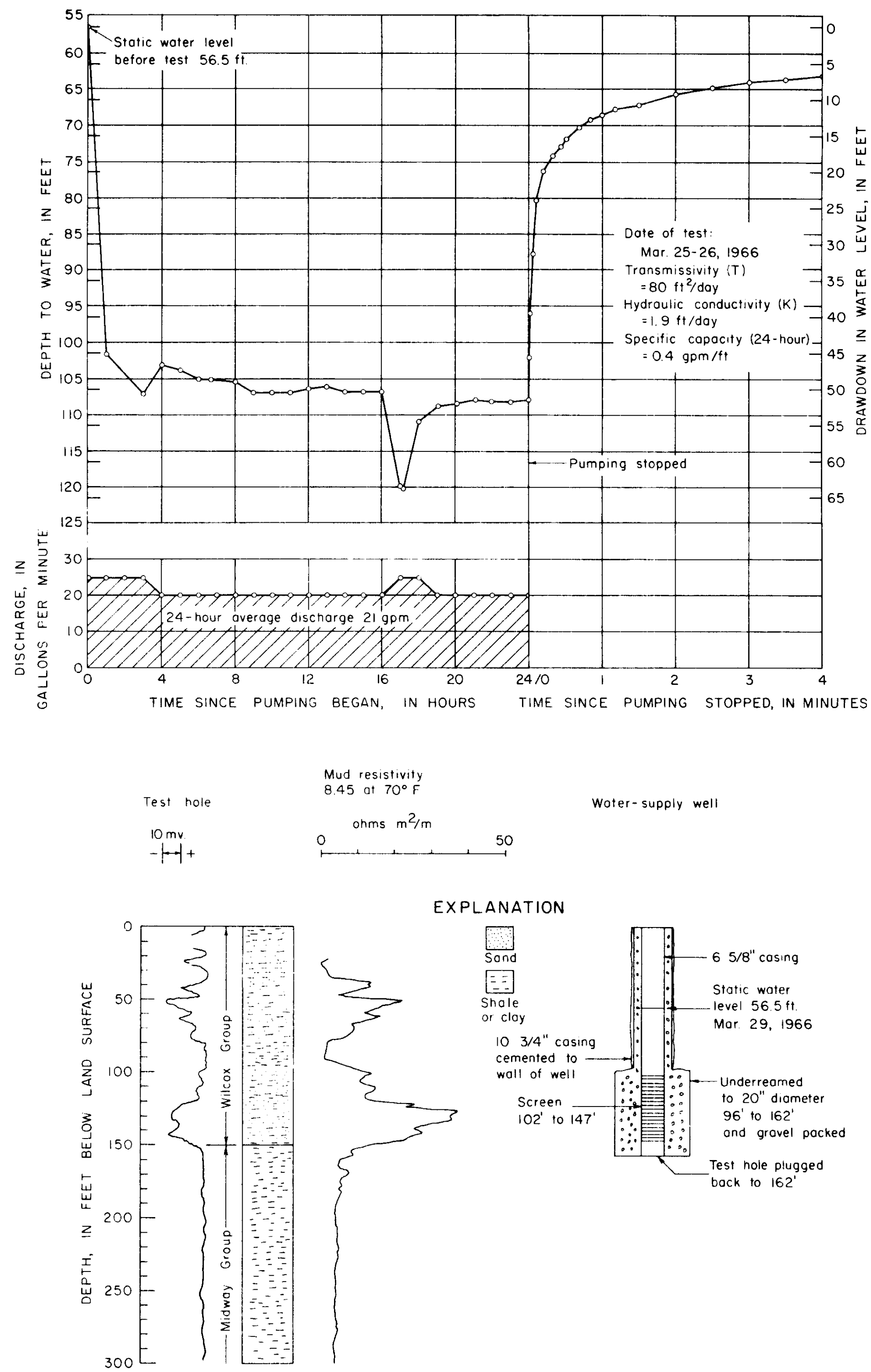


Figure 11

Log, Material Setting, and Results of an Aquifer Test in Well UX-34-10-602 in the Wilcox Group

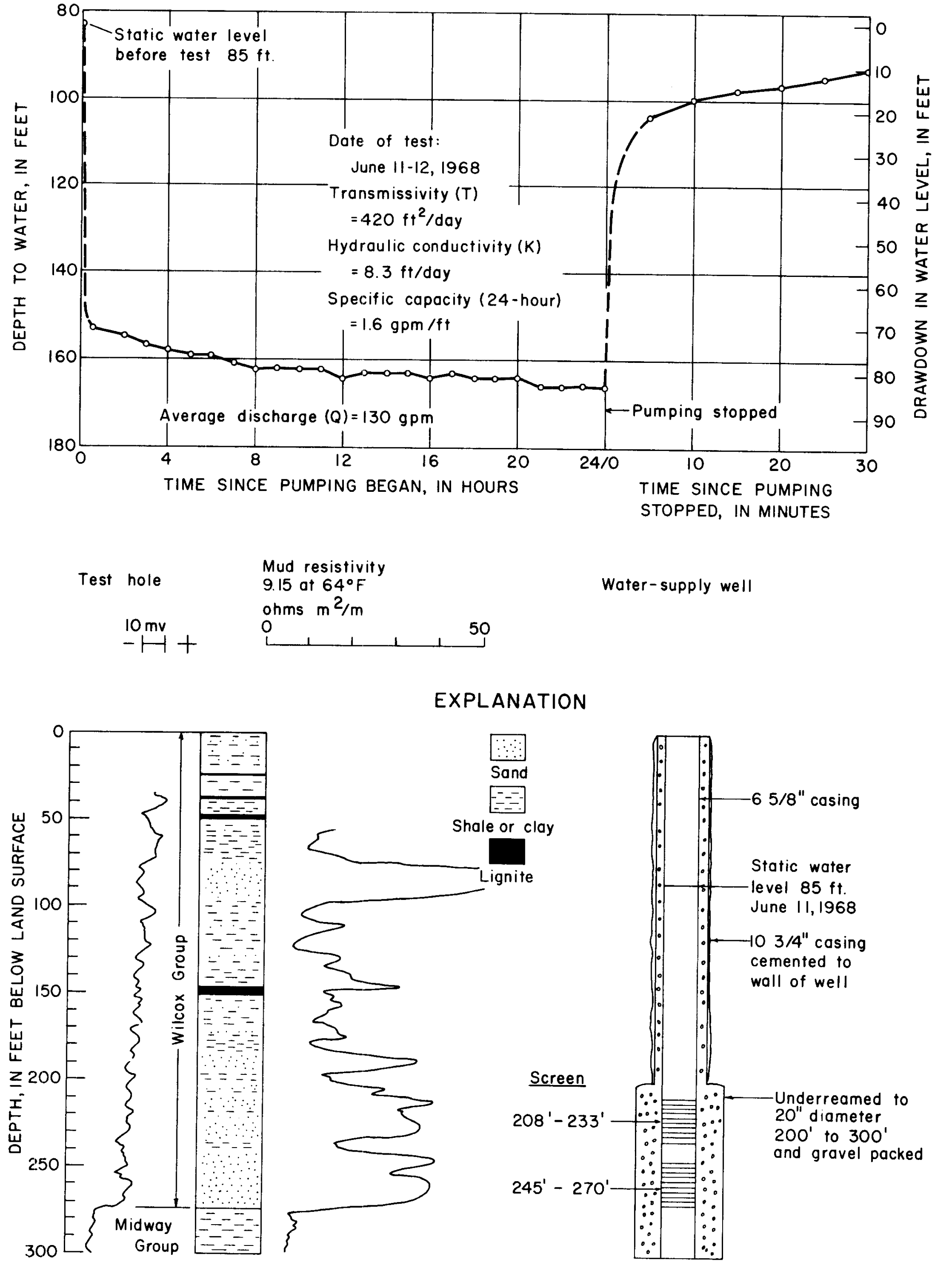
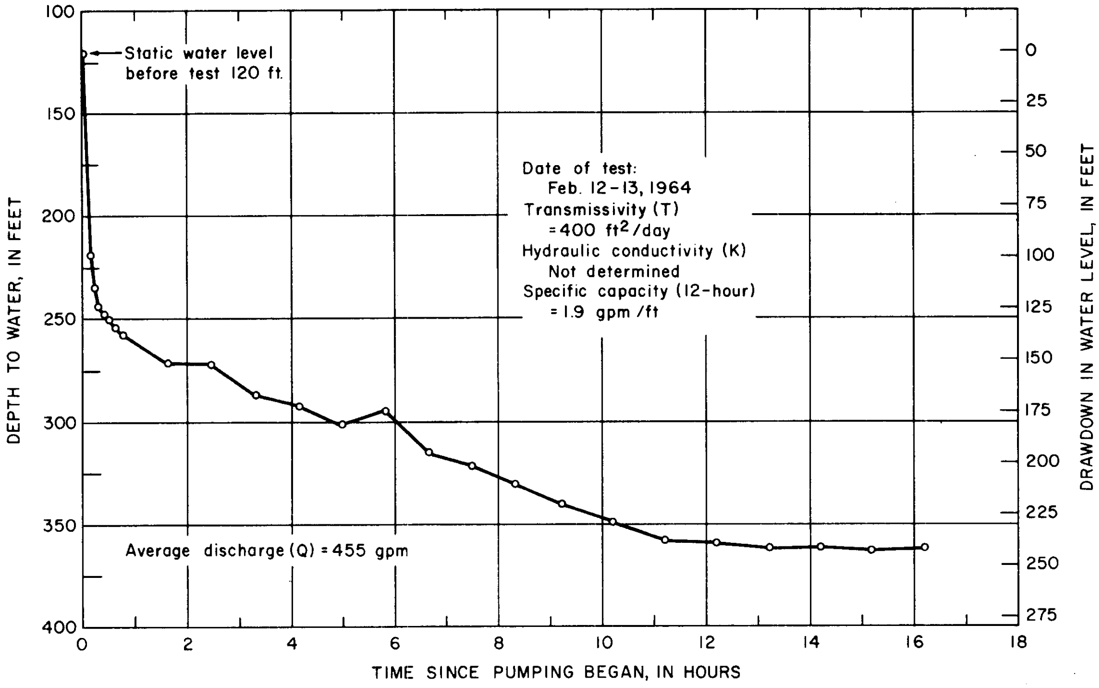


Figure 12

Log, Material Setting, and Results of an Aquifer Test in Well YS-34-17-901 in the Wilcox Group



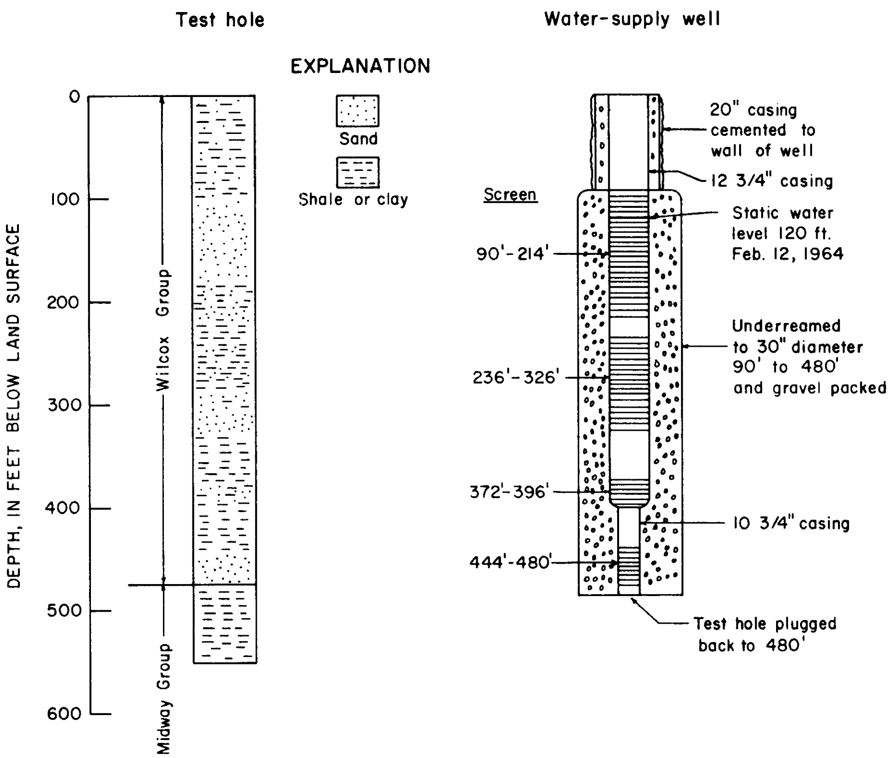


Figure 13

Log, Material Setting, and Results of an Aquifer Test in Well YS-34-18-602 in the Wilcox Group

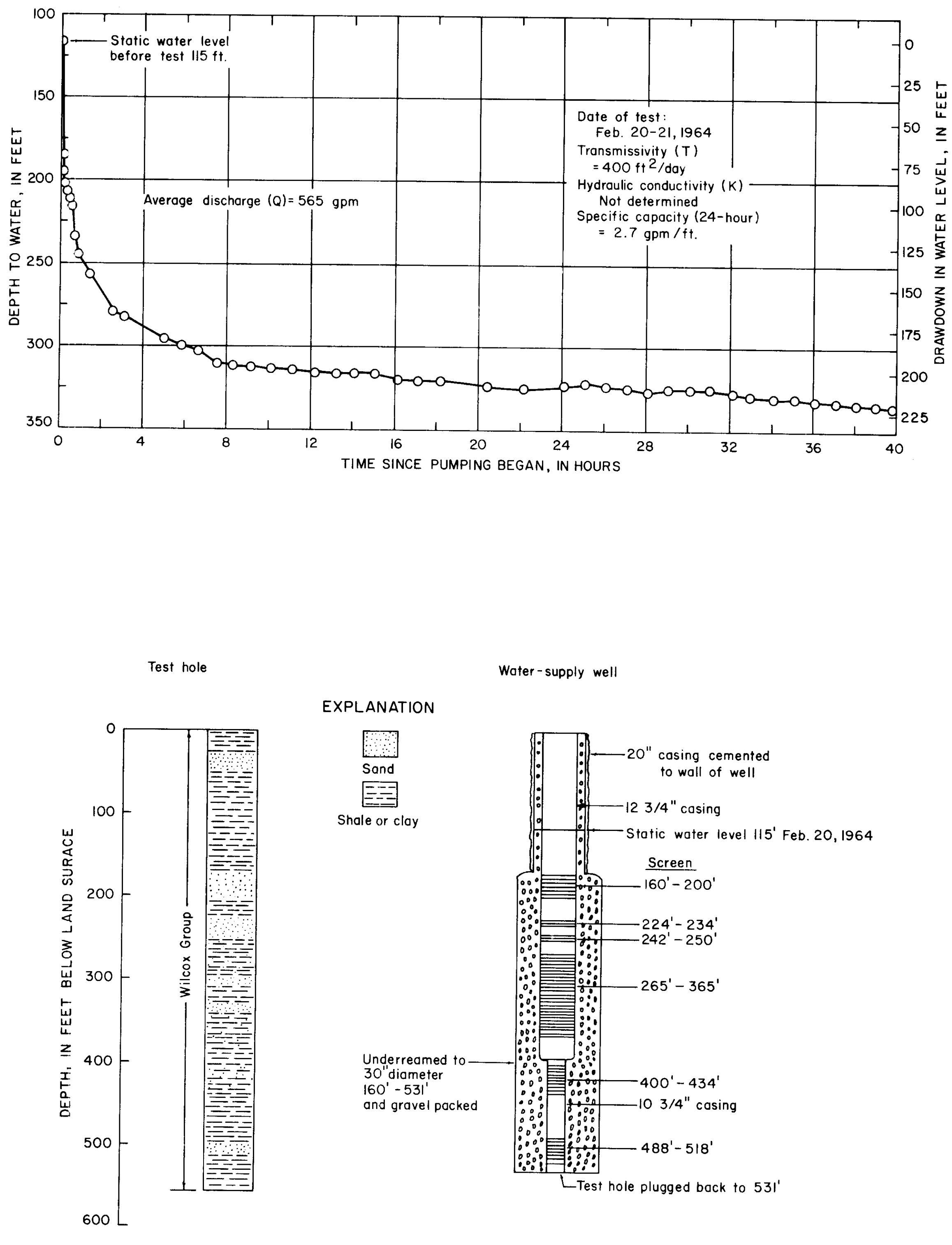
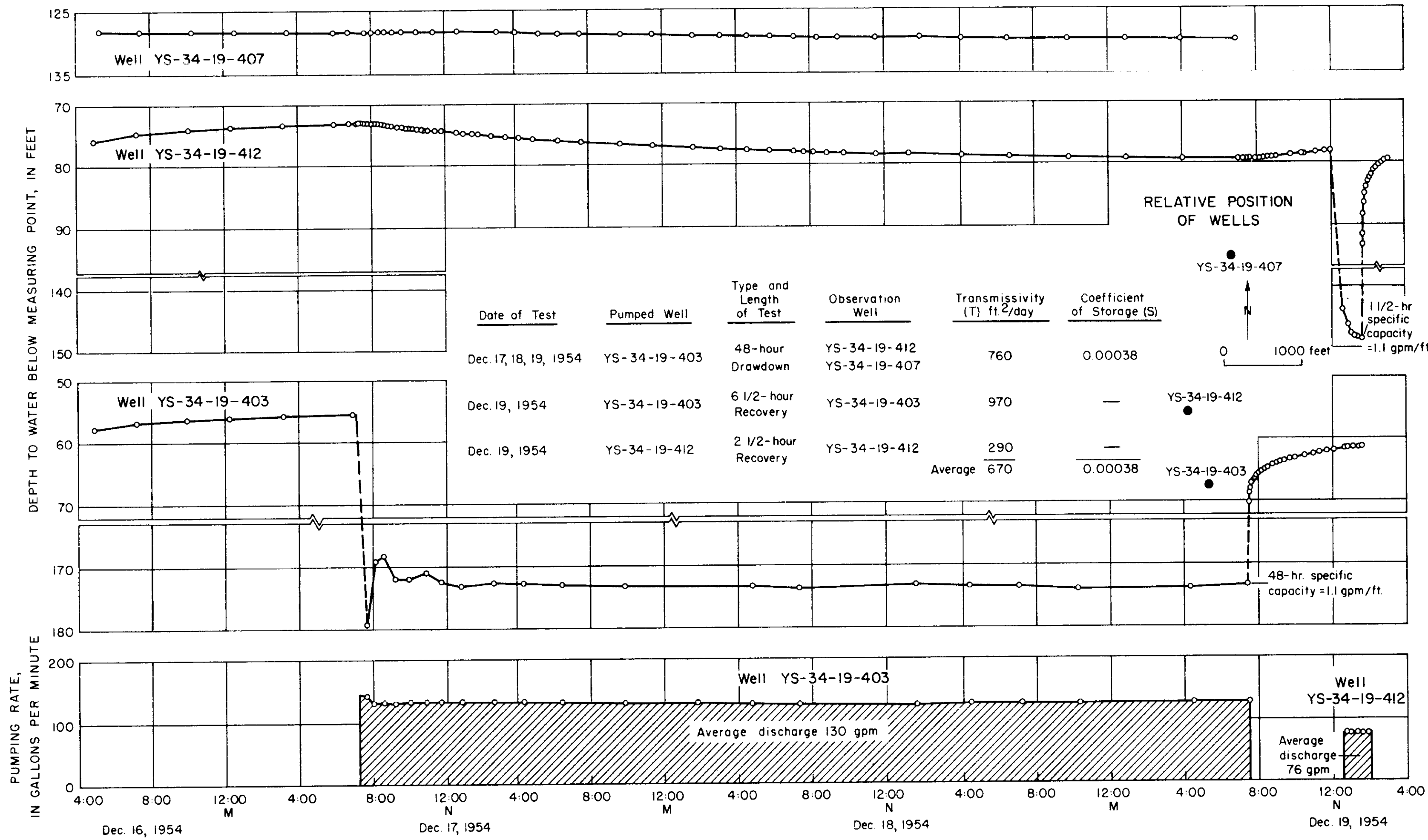


Figure 14

Log, Material Setting, and Results of an Aquifer Test in Well YS-34-19-408 in the Wilcox Group



Date of Test	Pumped Well	Type and Length of Test	Observation Well	Transmissivity (T) ft.^{2}/day	Coefficient of Storage (S)
Dec. 17, 18, 19, 1954	YS-34-19-403	48-hour Drawdown	YS-34-19-412 YS-34-19-407	760	0.00038
Dec. 19, 1954	YS-34-19-403	6 1/2-hour Recovery	YS-34-19-403	970	—
Dec. 19, 1954	YS-34-19-412	2 1/2-hour Recovery	YS-34-19-412	290	—
			Average	670	0.00038

Figure 15

Results of Aquifer Tests in Wells Tapping the Wilcox Group at Grand Saline

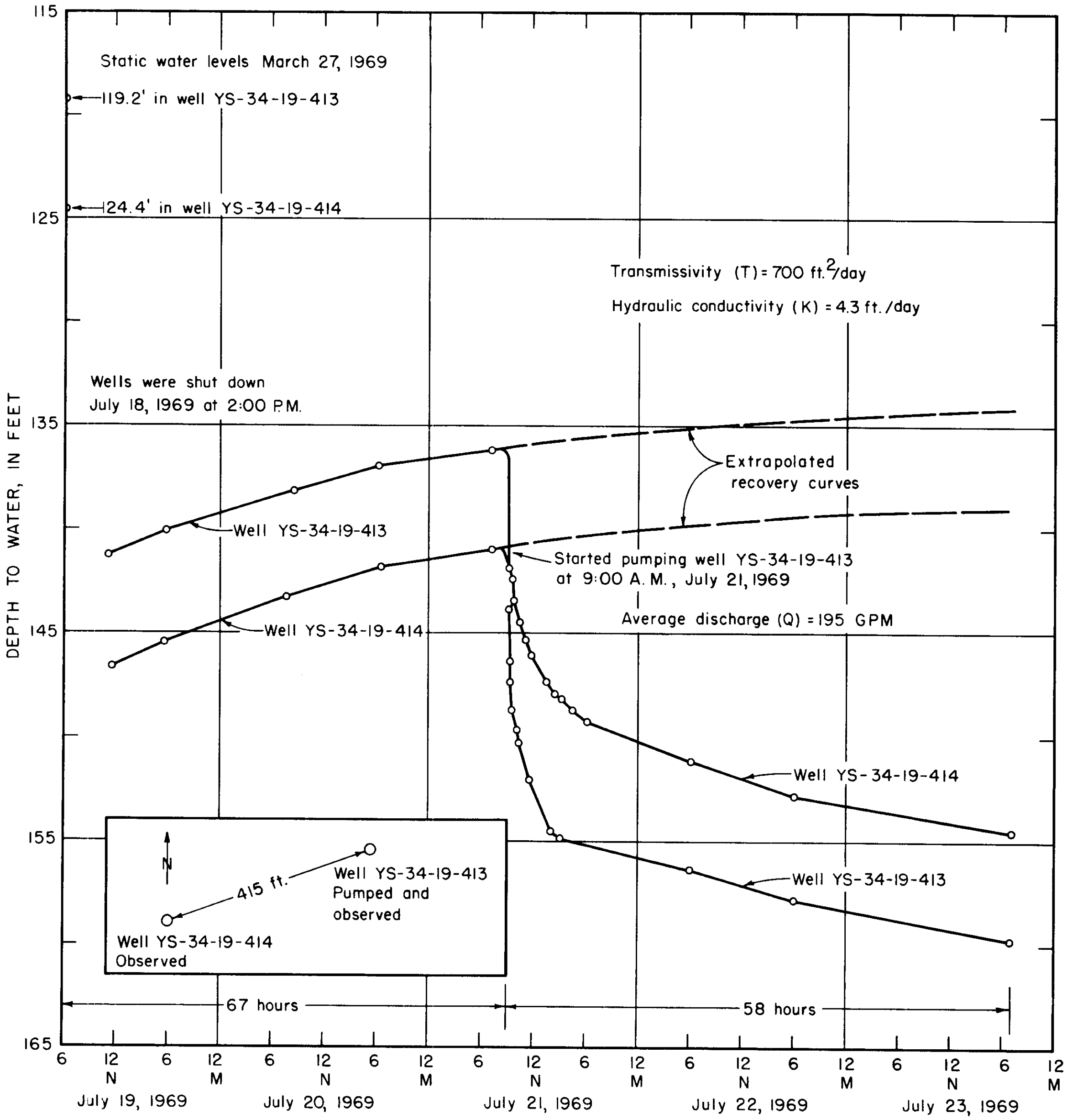


Figure 16

Results of Aquifer Tests in Wells YS-34-19-413 and YS-34-19-414 in the Wilcox Group

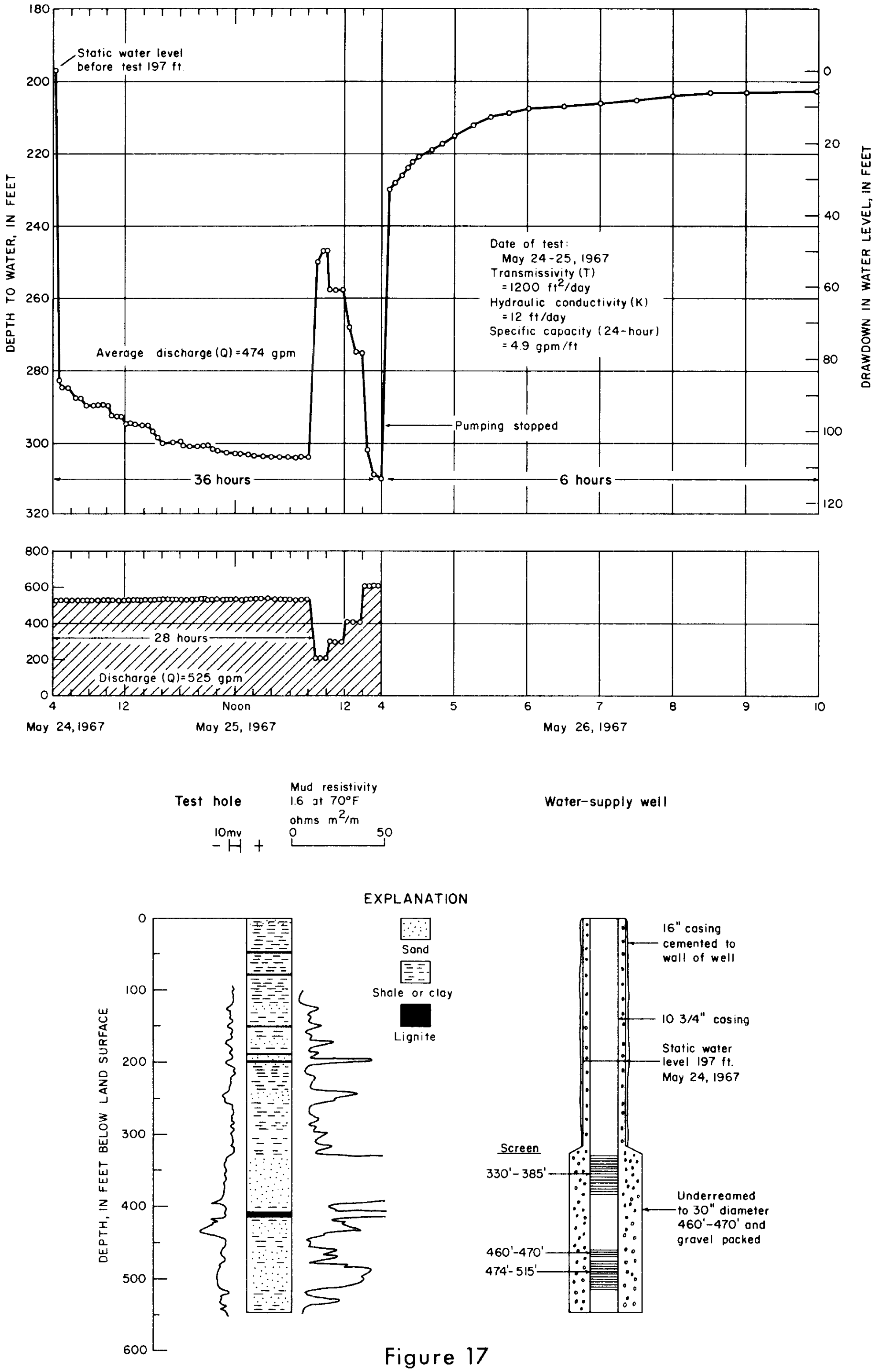


Figure 17

Log, Material Setting, and Results of an Aquifer Test in Well YS-34-19-415 in the Wilcox Group

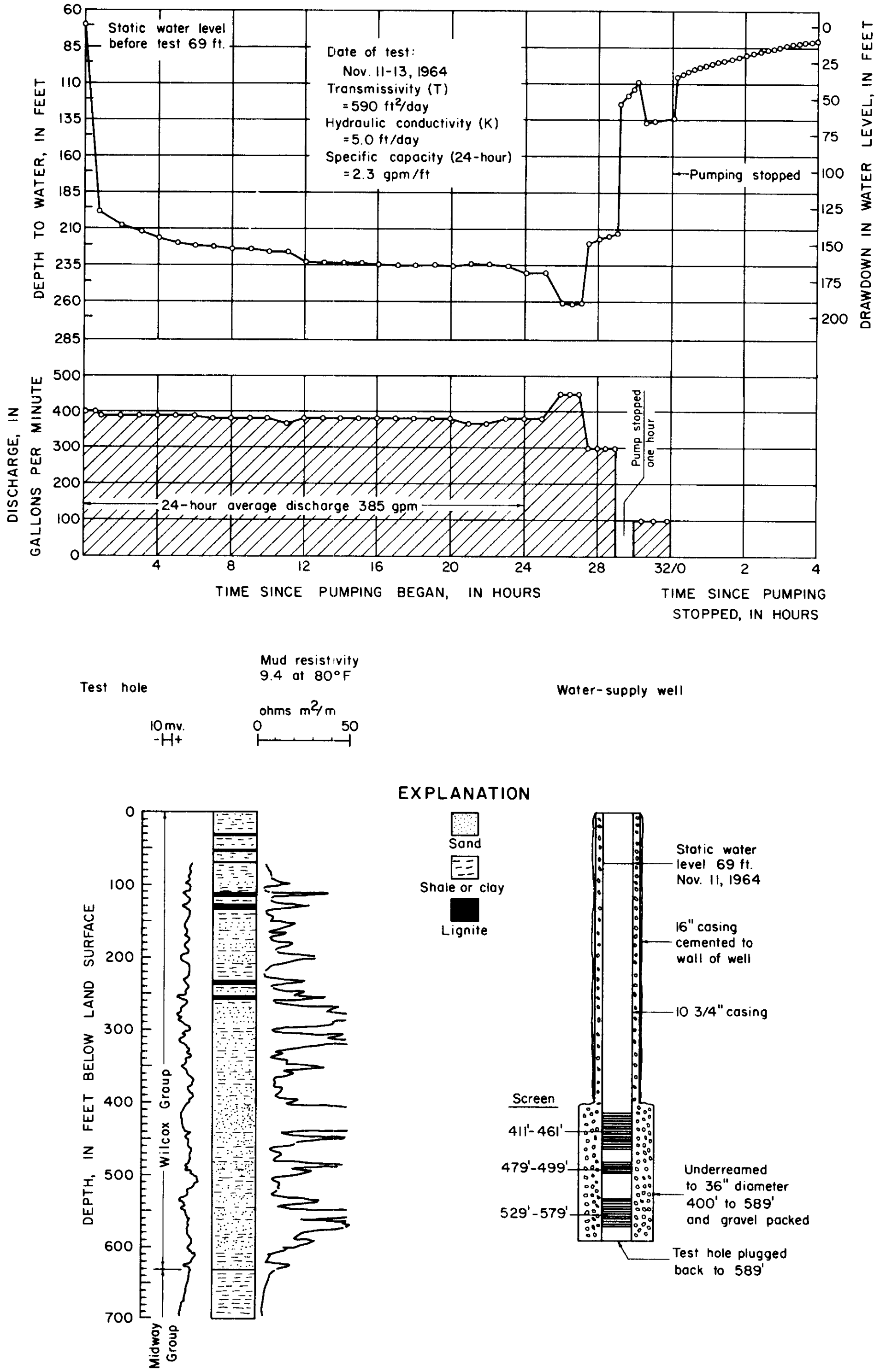


Figure 18

Log, Material Setting, and Results of an Aquifer Test in Well XH-34-28-405 in the Wilcox Group

p. 24) reported that coefficients of transmissibility and permeability of 3,200 gpd per foot (430 ft^2 per day) and 30 gpd per square foot (4.0 ft per day) were probably representative of the Queen City aquifer.

Use of Water

Since 1913, the Texas Water Rights Commission and its antecedent agencies have inventoried the annual surface-water diversions within the State. In 1965, the Texas Water Development Board (then Texas Board of Water Engineers) initiated a similar statewide survey of ground-water pumpage for municipal and rural water systems, and industrial supply.

Table 2 shows the reported 1965-69 pumpage for municipal supply and industrial use in Rains and Van Zandt Counties. The table also shows the source of water. Figure 19 summarizes the reported 1965-69 pumpage according to the sources and uses of water. Table 3 and Figure 19 do not include water that is pumped from privately owned wells or from earthen tanks used for domestic supply and livestock, or irrigation.

The reported use of water in Rains and Van Zandt Counties during 1969 was small, totaling only 779 million gallons or 2,391 acre-feet (Figure 19). However, the demand for water has increased by nearly 36 percent since 1965. If the trend continues, the annual demand may be as much as 2,000 million gallons or about 6,000 acre-feet by 1979.

Table 2.—Reported Use of Water, 1965-69

USE OF WATER	PUMPAGE IN MILLION GALLONS				
	1965	1966	1967	1968	1969
RAINS COUNTY					
Municipal (includes rural water-supply corporations)	20.23	20.93	20.72	22.88	26.15
Industrial	—	—	3.65	3.66	.96
Source					
Ground water	10.86	10.89	14.35	16.70	14.96
Surface water	9.37	9.94	10.02	9.84	12.15
COUNTY TOTALS	20.23	20.93	24.37	26.54	27.11
VAN ZANDT COUNTY					
Municipal (includes rural water-supply corporations)	279.47	284.21	333.35	364.30	415.27
Industrial	274.48	320.09	295.05	331.94	336.84
Source					
Ground water	358.55	410.15	433.94	466.54	477.66
Surface water	195.40	194.15	194.46	229.70	274.45
COUNTY TOTALS	553.95	604.30	628.40	696.24	752.11

Municipal and Rural Supply

The reported municipal and rural pumpage in 1969 was 26.15 million gallons in Rains County and 415.27 million gallons in Van Zandt County; a total of 441.42 million gallons (1,354 ac-ft). In addition, the city of Van pumped 4,485,000 gallons from well XH-34-28-405 and 84,170,193 gallons from a municipal lake, both of which are 2 miles northeast of the city limits in Smith County. Another well in Smith County, XH-34-28-202, supplied water for a few residents in northeastern Van Zandt County. Two wells drilled for a water-supply corporation in Hopkins County reportedly supplied 30 families in northern Rains County in 1969.

Part of the water pumped from well YS-34-36-901 in southeastern Van Zandt County is piped to rural areas in Henderson and Smith Counties. A very large quantity of water, nearly 50,000 acre-feet, was piped from Lake Tawakoni to the city of Dallas in 1969.

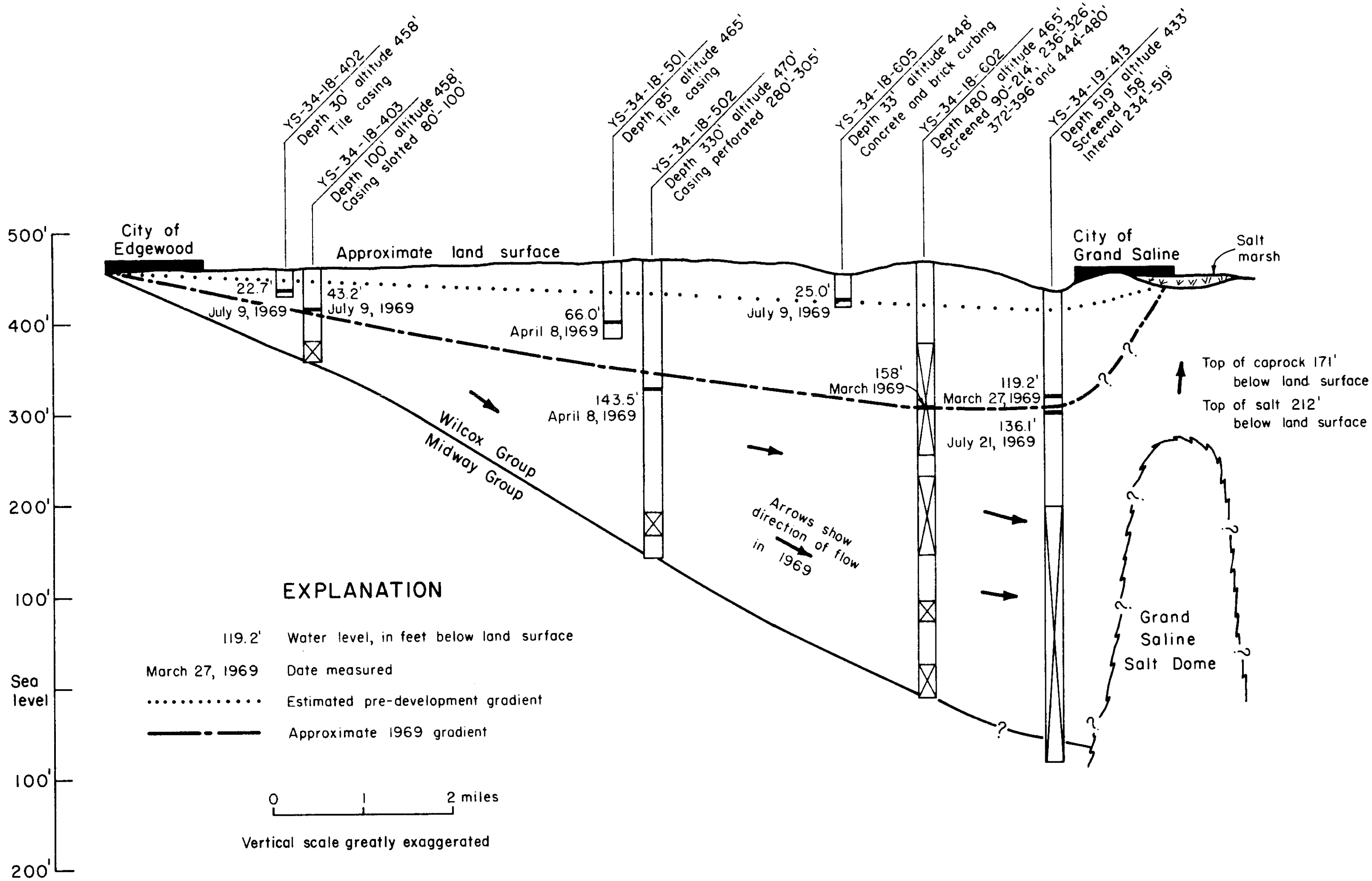


Figure 20

Water-Level Profiles in the Heavily-Pumped Sands in the Wilcox Group Between Grand Saline and Edgewood

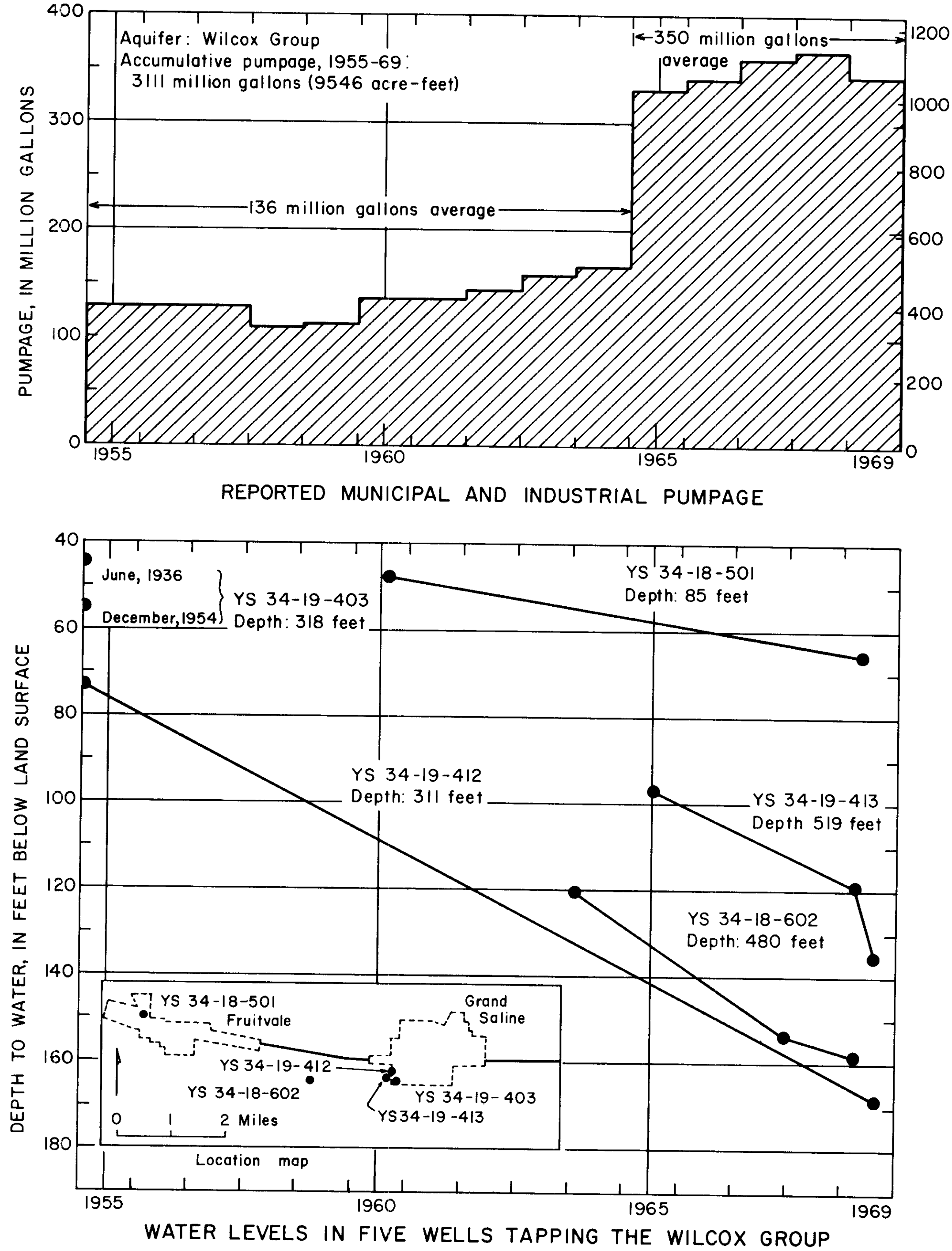


Figure 21

Municipal and Industrial Pumpage and Declines in Water Levels in the Vicinity of Grand Saline

Once a site is selected, the wells are usually completed through procedures summarized below:

1. Surface casing, 10 to 20 inches in diameter, is set to the top of the producing zone, and the annular space between the casing and the wall is filled with cement.

2. The well is underreamed to 20 or 30 inches in diameter from the base of the surface casing to the bottom of the well.

3. Six- to 12.inch production casing with screens and back-pressure valves are lowered through the surface casing. The screens are set in the water-bearing sands that were logged in the test hole; the back-pressure valve is set at the bottom.

4. Gravel is placed between the wall of the well and production casing. The gravel minimizes head loss and prevents sand from clogging the ,well and distribution system.

5. A test pump is installed and the well is developed by pumping at varying rates to remove the drilling mud, silt, and clay from the aquifer. Additional gravel is added as the fine material is removed and the effective well diameter is increased.

6. After the well is developed, a pumping test is made to determine the hydraulic properties of the aquifer.

7. The well is equipped with a pump and column pipe commensurate with the permeability of the aquifer, required production, and pumping lifts.

8. Equipment to chlorinate, fluoridate, and soften the water may or may not be installed, depending upon the quality of the raw water and its intended use.

The industrial and public-supply wells are equipped with either turbine or submergible pumps. The pump motors and column pipes generally range in size from 5 to 30 horsepower and 4 to 6 inches in diameter, respectively.

A few of the older industrial wells in Van Zandt County are equipped with 50 to 100 horsepower turbines and 8-inch column pipes. However, these wells are pumped for only short periods because of the large drawdowns in water levels. If smaller pumps and column pipes were installed, the same amount of water could be produced more economically by pumping these wells more continuously. Some of the industrial wells were screened at or near the static water levels (Figures 13 and 14). When these wells are pumped, and the water level in the wells decline below the upper sands, water cascades into the well and creates turbulence, thereby reducing pump efficiency.

Rural-Domestic and Livestock Wells

Prior to 1940, most of the shallow domestic and stock wells in Rains and Van Zandt Counties were dug by hand. The wells were generally curbed with brick or rock; the diameters generally ranged from 3 to 4 feet. Since 1940, most of the shallow wells have been bored by bucket-type augers whose operating depths are limited to about 50 feet. Concrete tile, about 30 inches in diameter, is used for curbing. Gravel is packed in the bottom of the well and is placed outside the tile to control sand entry and prevent caving.

Although wells of this type are relatively inexpensive and are capable of storing considerable quantities of water, they are subject to contamination from sewage and from stockyards. Some of the shallow wells go dry during droughts, or fail when they are heavily pumped during the summer.

In recent years, an increasing number of livestock and domestic-supply wells have been drilled to the deeper water-bearing sands. These wells are generally cased with 2- to 5-inch diameter steel or plastic pipe and are finished with 2- to 3-inch diameter screens or perforated liners, which project upward a few feet into the casing. Because corrosive water is frequently encountered in sands at intermediate depths, most drillers set a packer above the perforations and cement the casing to the wall of the well. This procedure is recommended for all wells drilled to depths greater than 100 feet.

Most of the domestic and stock wells are equipped with water-jet, cylinder, centrifugal, or submergible pumps powered by one-quarter to one-half horsepower electric motors. However, ropes and buckets remain in use in some of the rural areas.

QUALITY OF WATER

The suitability of a water supply is controlled largely by the restrictions imposed by the contemplated use of the water. Various standards have been established for dissolved solids; bacterial content; and physical properties such as temperature, odor, color, and turbidity. Bacterial content and undesirable physical properties may warrant concern, but generally the water can be treated by simple and inexpensive processes. The removal of dissolved solids, however, may be difficult and expensive.

The source and significance of dissolved solids in water is summarized in Table 3. Chemical analyses of water from wells are given in Table 5. The specific conductance, hardness, sulfate, and chloride concentrations in water from wells is shown on Figure 22. Analyses of water from lakes and streams are given in Table 6. The locations of the wells, lakes, and streams from which water was sampled are shown in Figure 26.

Table 3.—Source and Significance of Dissolved-Mineral Constituents and Properties of Water

CONSTITUENT OR PROPERTY	SOURCE OR CAUSE	SIGNIFICANCE
Silica (SiO_2)	Dissolved from practically all rocks and soils, commonly less than 30 mg/l. High concentrations, as much as 100 mg/l, generally occur in highly alkaline waters.	Forms hard scale in pipes and boilers. Carried over in steam of high pressure boilers to form deposits on blades of turbines. Inhibits deterioration of zeolite-type water softeners.
Iron (Fe)	Dissolved from practically all rocks and soils. May also be derived from iron pipes, pumps, and other equipment. More than 1 or 2 mg/l of iron in surface waters generally indicates acid wastes from mine drainage or other sources.	On exposure to air, iron in ground water oxidizes to reddish-brown precipitate. More than about 0.3 mg/l stains laundry and utensils reddish-brown. Objectionable for food processing, textile processing, beverages, ice manufacture, brewing, and other processes. U.S. Public Health Service (1962) drinking-water standards state that iron should not exceed 0.3 mg/l. Larger quantities cause unpleasant taste and favor growth of iron bacteria.
Calcium (Ca) and magnesium (Mg)	Dissolved from practically all soils and rocks, but especially from limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Magnesium is present in large quantities in sea water.	Cause most of the hardness and scale-forming properties of water; soap consuming (see hardness). Waters low in calcium and magnesium desired in electroplating, tanning, dyeing, and in textile manufacturing.
Sodium (Na) and potassium (K)	Dissolved from practically all rocks and soils. Found also in ancient brines, sea water, industrial brines, and sewage.	Large amounts, in combination with chloride, give a salty taste. Moderate quantities have little effect on the usefulness of water for most purposes. Sodium salts may cause foaming in steam boilers and a high sodium content may limit the use of water for irrigation.
Bicarbonate (HCO_3) and carbonate (CO_3)	Action of carbon dioxide in water on carbonate rocks such as limestone and dolomite.	Bicarbonate and carbonate produce alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot water facilities to form scale and release corrosive carbon dioxide gas. In combination with calcium and magnesium, cause carbonate hardness.
Sulfate (SO_4)	Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Commonly present in mine waters and in some industrial wastes.	Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts, sulfate in combination with other ions gives bitter taste to water. Some calcium sulfate is considered beneficial in the brewing process. U.S. Public Health Service (1962) drinking-water standards recommend that the sulfate content should not exceed 250 mg/l.
Chloride (Cl)	Dissolved from rocks and soils. Present in sewage and found in large amounts in ancient brines, sea water, and industrial brines.	In large amounts in combination with sodium, gives salty taste to drinking water. In large quantities, increases the corrosiveness of water. U.S. Public Health Service (1962) drinking-water standards recommend that the chloride content should not exceed 250 mg/l.
Fluoride (F)	Dissolved in small to minute quantities from most rocks and soils. Added to many waters by fluoridation of municipal supplies.	Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth, depending on the concentration of fluoride, the age of the child, amount of drinking water consumed, and susceptbility of the individual. (Maier, 1950)
Nitrate (NO_3)	Decaying organic matter, sewage, fertilizers, and nitrates in soil.	Concentration much greater than the local average may suggest pollution. U.S. Public Health Service (1962) drinking-water standards suggest a limit of 45 mg/l. Waters of high nitrate content have been reported to be the cause of methemoglobinemia (an often fatal disease in infants) and therefore should not be used in infant feeding. Nitrate has been shown to be helpful in reducing inter-crystalline cracking of boiler steel. It encourages growth of algae and other organisms which produce undesirable tastes and odors.
Dissolved solids	Chiefly mineral constituents dissolved from rocks and soils. Includes some water of crystallization.	U.S. Public Health Service (1962) drinking-water standards recommend that waters containing more than 500 mg/l dissolved solids not be used if other less mineralized supplies are available. Waters containing more than 1000 mg/l dissolved solids are unsuitable for many purposes.
Hardness as $CaCO_3$	In most waters nearly all the hardness is due to calcium and magnesium. All the metallic cations other than the alkali metals also cause hardness.	Consumes soap before a lather will form. Deposits soap curd on bathtubs. Hard water forms scale in boilers, water heaters, and pipes. Hardness equivalent to the bicarbonate and carbonate is called carbonate hardness. Any hardness in excess of this is called non-carbonate hardness. Waters of hardness as much as 60 ppm are considered soft; 61 to 120 mg/l, moderately hard; 121 to 180 mg/l, hard; more than 180 mg/l, very hard.
Specific conductance (micromhos at 25°C)	Mineral content of the water.	Indicates degree of mineralization. Specific conductance is a measure of the capacity of the water to conduct an electric current. Varies with concentration and degree of ionization of the constituents.
Hydrogen ion concentration (pH)	Acids, acid-generating salts, and free carbon dioxide lower the pH. Carbonates, bicarbonates, hydroxides, and phosphates, silicates, and borates raise the pH.	A pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. pH is a measure of the activity of the hydrogen ions. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline waters may also attack metals.

Standards for Water Quality

The U.S. Public Health Service has established and periodically revises the standards for drinking water to be used on common carriers engaged in interstate commerce. The standards are designed to protect the traveling public and may be used to evaluate domestic and public water supplies. According to the U.S. Public Health Service (1962), dissolved-mineral constituents should not be present in a public water supply in excess of concentrations shown in the following table, except where more suitable water is not available or cannot be made available at reasonable cost.

CONSTITUENT	CONCENTRATION IN (MILLIGRAMS PER LITER)
Iron (Fe)	0.3
Sulfate (SO_4)	250
Chloride (Cl)	250
Nitrate (NO_3)	45
Dissolved solids	500

Iron in concentrations of more than 0.3 mg/l (milligrams per liter) will cause reddish-brown stains on clothes and porcelain fixtures and encrustations or scale in pipes or other water conduits and containers. Sulfate in excess of 250 mg/l may produce a laxative effect. Chloride in excess of 250 mg/l in combination with sodium will give a salty taste and will increase corrosion. Nitrate in excess of 45 mg/l may be pathologically detrimental. Where excessive concentrations of nitrate occur locally, it is frequently the result of organic pollution from sewage facilities.

Chemical requirements for industrial uses of water vary according to the industry, but they are fairly rigid where water is used in food, paper, and some chemical-process industries. The most common industrial uses of water in Rains and Van Zandt Counties are for cooling, boiler feed, and water-flooding of oil reservoirs. Excessive concentrations of dissolved solids is a problem in water used for cooling because they tend to accelerate corrosion (California State Water Pollution Control Board, 1963).

The use of water for boiler feed requires strict limits on the amount of dissolved-solids and silica, because scale may form in boilers. High-pressure systems, operating at a pressure of more than 400 psi (pounds per square inch), require a dissolved-solids content of 50 mg/l or less, and a silica content of not more than 1 mg/l; low-pressure systems, less than 150 psi, can use water having as much as 3,000 mg/l dissolved solids and 40 mg/l silica (Moore, 1940).

According to the U.S. Salinity Laboratory Staff (1954), some of the principal factors that determine the quality of water for irrigation are the concentrations of dissolved solids, sodium, and boron. The relative importance of the dissolved constituents in irrigation water is dependent upon the degree to which they accumulate in the soil.

Sodium is a significant factor in evaluating irrigation water because a high SAR (sodium-adsorption ratio) may cause the soil structure to break down. The RSC (residual sodium carbonate) is another factor used in assessing the quality of water for irrigation. According to Wilcox (1955), water containing more than 2.5 me/l (milliequivalents per liter) RSC is not suitable for irrigation; 1.25 to 2.5 me/l is marginal; and less than 1.25 me/l probably is safe. However, the suitability of water for irrigation cannot be evaluated on chemical content alone. The type of soil, adequacy of drainage, salt tolerance of crops, and frequency and amount of rainfall must also be considered.

Quality of Surface Water

Table 6 shows 164 analyses of water sampled from streams and lakes in Rains and Van Zandt Counties and adjacent areas. Most of the samples (151) were from six lakes and seven streams in the Sabine River Basin; 12 were from the Neches River and its tributaries, and one was from Cedar Creek in the Trinity River Basin. The 21 surface-water sampling sites are shown on Figure 26.

With only a few local exceptions, the streams and lakes supply water that is chemically suitable for all purposes. The dissolved solids are normally less than 500 mg/l.

Analyses of 17 samples of untreated water from Lake Tawakoni and five municipal lakes showed that dissolved solids ranged from 33 to 230 mg/l and averaged 126 mg/l (Table 6). Hardness ranged from 16 to 102 mg/l and averaged 58 mg/l. All of the water may be classed as soft or moderately hard. The sulfate and chloride concentrations were well below the recommended limits of 250 mg/l.

These analyses are considered to represent the quality of surface water used within the report area. Locally, however, the quality of water has been degraded through natural processes or by man's activities. Consequently, some of the water is unfit for human consumption. (See section on Water-Quality Problems.)

Quality of Ground Water

Table 5 shows 173 analyses of water from 165 wells in Rains and Van Zandt Counties and adjacent areas. Most of the samples (145) were from wells tapping the Carrizo-Wilcox aquifer, 13 were from the Queen City aquifer, 12 were from the Midway Group, two were from the Reklaw Formation, and one was from the Carrizo Sand and the Reklaw Formation. Figure 22 shows the specific conductance, hardness, sulfate, and chloride content in water from 164 wells. The depths of the wells are given to show both lateral and vertical changes in water quality. A graph illustrating the relation between specific conductance and dissolved solids is included on the figure. Using this graph, it is possible to estimate the dissolved solids from the specific conductance.

The chemical analyses shown in Table 5 and Figure 22 are considered to represent the quality of water pumped from wells in and near the report area. Most of the samples collected, about 90 percent of the total, contained less than 1,000 mg/l dissolved solids; approximately 93 percent contained less than 250 mg/l chloride or sulfate, about 90 percent contained less than 45 mg/l nitrate, 53 percent contained less than 0.3 mg/l iron, and 63 percent were either soft or moderately hard.

During the investigation water was sampled from four wells (YS-34-17-903, YS-34-27-801, YS-34-34-801, and YS-34-33-404) for pesticide analyses. No measurable concentrations of either insecticides or herbicides were found in these samples.

Water-Quality Problems

Although surface and ground water in Rains and Van Zandt Counties normally contain small or moderate amounts of dissolved solids, some of the water has excessive concentrations of one or more chemical constituents which may require treatment or may preclude its use for certain purposes.

Excessive iron and acidity is frequently a problem in wells completed in sands at intermediate depths. The extent and position of this intermediate zone varies within the report area. However, the problem appears to be most pronounced in wells screened opposite sands 50 to 100 feet below the surface.

Hardness exceeding 120 mg/l was measured in 37 percent of the ground-water samples. However, both hardness and iron can be removed through chemical treatment and filtration. Consequently, neither is considered to be a serious problem.

Of more concern are the large concentrations of nitrate in the water from some of the shallow wells. Table 5 shows that eight of the 87 wells sampled for nitrate had concentrations exceeding 45 mg/l. The wells, their depths, and the nitrate concentrations are listed below. Probably most of the wells have been contaminated by sewage effluent or by seepage from stockyards.

WELL	DEPTH (FEET)	NITRATE (MG/L)
UX-34-03-701	25	305
UX-34-11-202	45	525
YS-34-17-501	36	120 est.
YS-34-17-601	35	396
YS-34-27-502	31	100
YS-34-27-801	60	243
YS-34-33-404	42	73
YS-34-36-604	23	129

Because the shallow wells are highly susceptible to both organic and inorganic contamination, periodic bacterial and chemical analyses are recommended if the water is used for drinking. These analyses can be made by the Smith County Health Department in Tyler.

Disposal of Oil Field Brine

Disposal of brine in earthen pits in the Van oil field has degraded the quality of water in streams that drain the field. In compliance with a statewide “no-pit” order issued by the Railroad Commission of Texas, the use of salt-water disposal pits in the field was discontinued in 1968. Evidence cited below indicates that much of the brine that was placed in pits prior to 1968 was washed into streams that drain the oil field. However, a substantial amount has saturated the soils, and some has probably percolated downward to the water table.

The disposal of brine produced in the Van oil field has been described by Liddle (1936, p. 70), who wrote:

> “Salt water is collected by gravity gathering lines from tank batteries and local pits and is delivered into a two-million barrel earthen storage pit which has been excavated just northeast of the field. Water is here impounded and a considerable amount evaporates during the dry season. When Sabine River is in flood, salt water from the storage pit is turned into it through a dry creek. The distance from the pit to the river is 7 miles.”

The northern half of the Van oil field is drained by tributaries of Dry and Village Creeks (Figure 26). Residents in the area report that fish cannot survive in these creeks in and near the field. However, they also report that the quality of water has markedly improved since pit disposal was discontinued, and that fish are gradually migrating upstream.

the gaging station near Mineola (site 11 on Figure 26). Daily sampling of the flow at this station during the period October 1967 through September 1968 (Table 5) showed a discharge-weighted average concentration of dissolved solids of 131 mg/l, which is about normal for lakes and streams within the report area. However, the dissolved solids exceeded 500 mg/l in seven of the 56 composite samples, and was 2,350 mg/l in one sample, which indicates that during this period abnormally high salt loads were flushed from the drainage area upstream from this station.

AVAILABILITY OF GROUND WATER

The quantity of ground water available for future development is limited mainly by the low rate at which the aquifers transmit (conduct) water. An estimated 5,000 acre-feet could be annually withdrawn from the Carrizo-Wilcox aquifer without depleting water that is in storage. This is the amount that is effectively recharged to the aquifer, assuming the following physical and hydrologic properties:

1. Hydraulic conductivity of 6.3 feet per day
2. Sand thickness of 50 percent
3. Hydraulic gradient of 5 feet per mile
4. Contributing recharge area of 700 square miles

The 5,000 acre-feet of recharge compares favorably with the 3,000 acre-feet of recharge reported by Broom (1968, p.13) for the Carrizo-Wilcox aquifer in Wood County. In contrast to the small amount of water that is perennially available (5,000 ac-ft), a very large quantity of ground water is in storage. Assuming a 30 percent porosity, about 50 million acre-feet of water is stored in sands in the Carrizo-Wilcox aquifer. Approximately 17 million acre-feet is stored within a depth of 400 feet. Due to the low permeability of the aquifer, it is estimated that ten percent of the water in storage, or about 5 million acre-feet is economically retrievable through pumping wells.

Figure 25 shows areas in Rains and Van Zandt Counties that are favorable for future development of the Carrizo-Wilcox aquifer. The relative degrees of favorability—most favorable, favorable, and least favorable—are based on the yields and specific capacities of wells and the transmissivity of the water-bearing sands. The chemical quality of the water was not a criterion in determining areas of favorability.

The map shows that the most favorable area for additional development is in the southeastern half of the report area. Properly drilled and completed wells in this area can be expected to yield between 100 to 250 gpm. A few large-capacity wells in this area have pumped as much as 600 gpm during aquifer tests. However, these yields cannot be sustained during extended periods of pumping.

NEED FOR CONTINUING MEASUREMENTS OF WATER LEVELS

Additional development of the water resources of Rains and Van Zandt Counties is both feasible and inevitable. To record the changes in the water levels which will result from this development, a program of water-level measurements is needed.

The 20 wells listed below are recommended for measuring annual changes in levels in Rains and Van Zandt Counties. Seventeen of the wells tap the Wilcox Group (Carrizo-Wilcox aquifer) and three tap the Queen City Sand. Water levels were measured in all of the wells during this investigation; eight of the wells have historical records (Table 4).

WELL NO.	WELL NO.	WELL NO.
UX-34-03-101	YS-34-19-412	YS-34-34-201
UX-34-03-702	YS-34-19-413	YS-34-34-502
UX-34-10-501	YS-34-20-401	YS-34-34-503
UX-34-11-203	YS-34-25-602	YS-34-35-501
YS-34-17-903	YS-34-25-603	YS-34-36-103
YS-34-18-101	YS-34-28-102	YS-34-36-402
YS-34-18-501	YS-34-33-101	

The Carrizo-Wilcox aquifer has been extensively developed for municipal and industrial supply in and near the city of Grand Saline. Because of the resulting large declines in water levels, as much as 100 feet (Figures 20 and 21), additional development in this area should be avoided.

The area least favorable for development of the aquifer is along the feather edge of the Wilcox Group in western Rains and Van Zandt Counties. However, most of the residents in that area are, or soon will be, supplied by rural water systems which obtain water from Lake Tawakoni.

The Queen City aquifer has not been developed within the report area except for domestic and stock supplies. This aquifer is probably capable of yielding as much as 150 gpm to properly constructed wells. Because of its small extent, however, additional development will be restricted.

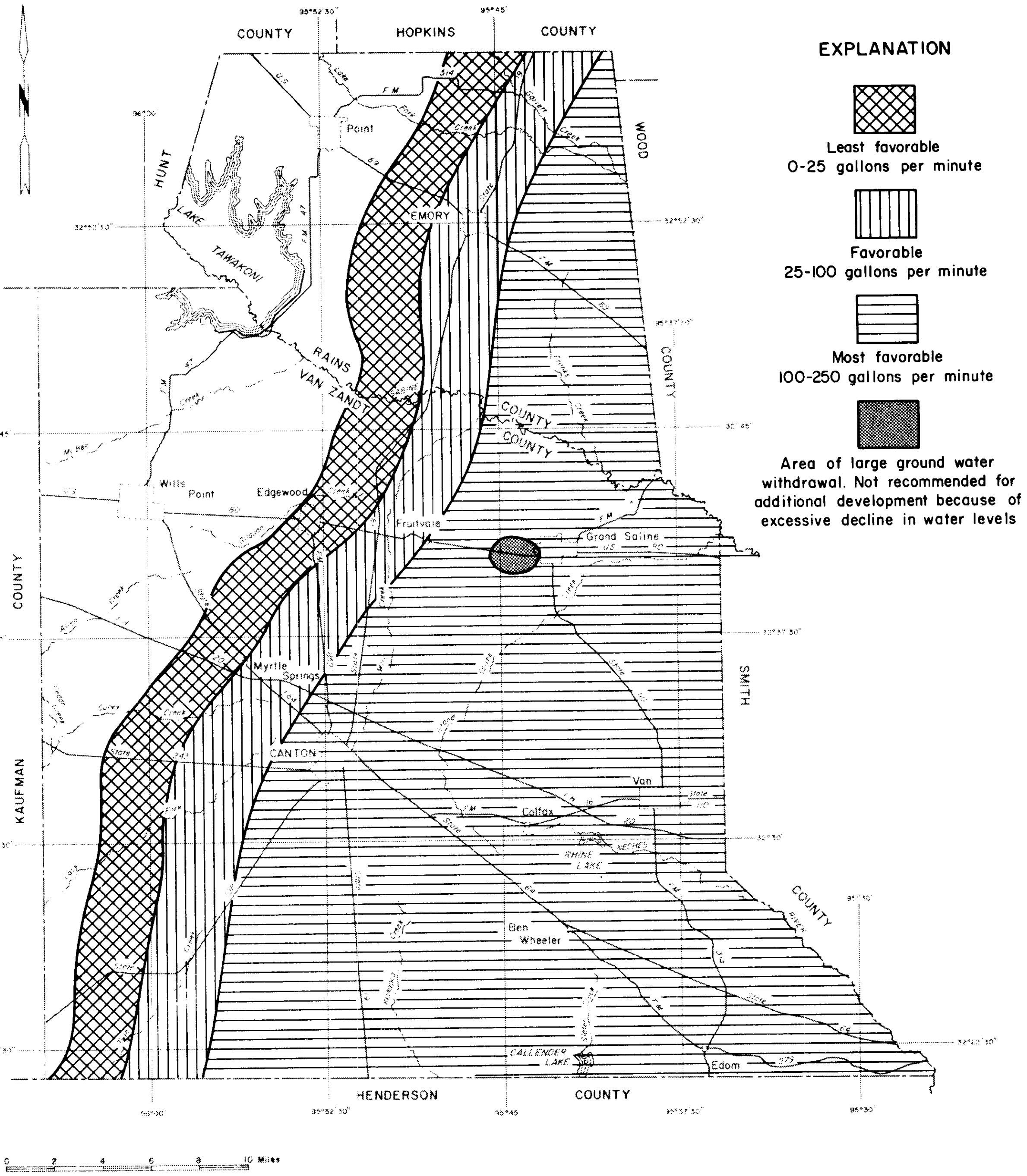


Figure 25

Estimated Potential Yields of Wells Tapping the Carrizo-Wilcox Aquifer

Base from U. S. Geological Survey topographic quadrangles

REFERENCES CITED

Baker, B. B., Dillard, J. W., Souders, V. L., and Peckham, R. C., 1963, Reconnaissance investigation of the ground-water resources of the Sabine River Basin, Texas: Texas Water Comm. Bull. 6307, 57 p.

Baldwin, H. L., and McGuinness, C. L., 1963, A primer on ground water: U.S. Geol. Survey Misc. Pub., 26 p.

Broadhurst, W. L., 1943, Records of wells, springs, drillers' logs, and water samples in Rains County, Texas: Texas Board Water Engineers duplicated rept., 13 p.

Broom, M. E., 1968, Ground-water resources of Wood County, Texas: Texas Water Devel. Board Rept. 79, 84 p.

California State Water Pollution Control Board, 1963, Water-quality criteria: California State Water Pollution Control Board Pub. 3A, 548 p.

Cooper, H. H., and Jacob, C. E., 1946, A generalized graphic method for evaluating formation constants and summarizing well-field history: Am. Geophys. Union Trans., v. 27, no. 4, p. 526-534.

Darton, N. Y., Stephenson, L. W., and Gardner, J. A., 1937, Geologic map of Texas.

Dillard, J. W., 1963, Availability and quality of ground water in Smith County, Texas: Texas Water Comm. Bull. 6302, 124 p.

Doll, W. L., Meyer, Gerald, and Archer, R. J., 1963, Water resources of West Virginia: West Virginia Dept. Nat. Resources, Div. of Water Resources, 134 p.

Fenneman, N. M., 1938, Physiography of eastern United States: New York, McGraw-Hill Book Co., 714 p.

Gillett, P. T., and Janca, I. G., 1965, Inventory of Texas irrigation, 1958 and 1964: Texas Water Comm. Bull. 6515, 317 p.

Green, R. S., and Love, S. K., 1967, Network to monitor hydrologic environment covers major drainage rivers: Pesticides Monitoring Journal, v. 1, no. 1, p. 13-16.

Hughes, L. S., and Leifeste, D. K., 1965, Reconnaissance of the chemical quality of surface waters of the Sabine River Basin, Texas and Louisiana: U.S. Geol. Survey Water-Supply Paper 1809-H, 71 p.

_____1967, Reconnaissance of the chemical quality of surface waters of the Neches River Basin, Texas: U.S. Geol. Survey Water-Supply Paper 1839-A, 63 p.

Kane, J. W., 1967, Monthly reservoir evaporation rates for Texas, 1940 through 1965: Texas Water Devel. Board Rept. 64, 111 p.

Leopold, L. B., and Langbein, W. E., 1960, A primer on water: U.S. Geol. Survey Misc. Pub., 50 p.

Liddle, R. A., 1936, the Van oil field, Van Zandt County, Texas: Texas Univ. Bull. 3601, 82 p.

Maier, F. J., 1950, Fluoridation of public water supplies: Am. Water Works Assoc. Jour., v. 42, pt. 1, p. 1120-1132.

Meinzer, O. E., 1923a, Occurrence of ground water in the United States, with a discussion of principles: U.S. Geol. Survey Water-Supply Paper 489, 231 p.

_____1923b, Outline of ground-water hydrology with definitions: U.S. Geol. Survey Water-Supply Paper 494, 71 p.

Meinzer, O. E., and others, 1942, Physics of the earth, v. 9, Hydrology: New York, McGraw-Hill Book Co., Inc., 712 p.

Moore, E. W., 1940, Progress report of the committee on quality tolerances of water for industrial uses: New England Water Works Assoc. Jour., v. 54, p. 261-272.

Railroad Commission of Texas, 1968, Annual report of the Oil and Gas Div., 1967: Railroad Comm. Texas, 627 p.

Sellards, E. H., Atkins, W. S., Plummer, F. B., 1932, The geology of Texas, v.1, Stratigraphy: Univ. Texas Bull. 3232, Bur. Econ. Geology, 1007 p.

Stenzel, H. B., 1938, The geology of Leon County, Texas: Univ. Texas Bull. 3818, Bur. Econ. Geology, 295 p.

Sundstrom, R. W., Hastings, W. W., and Broadhurst, W. L., 1948, Public water supplies in eastern Texas: U.S. Geol. Survey Water-Supply Paper 1047, 285 p.

Theis, C. V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage: Am. Geophys. Union Trans., v. 16, pt. 2, p. 519-524.

Todd, D. K., 1959, Ground-water hydrology: New York, John Wiley and Sons, Inc., 336 p.

Tolman, C. F., 1937, Ground water: New York, McGraw-Hill Book Co., Inc., 593 p.

U.S. Public Health Service, 1962, Public Health Service drinking-water standards: Public Health Service Pub. 956, 61 p.

U.S. Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkali soils: U.S. Dept. Agriculture Handb. 60, p. 69.

University of Texas, Bureau of Economic Geology, Geologic atlas of Texas: Tyler (1956) and Dallas (in press, 1969) sheets.

Wenzel, L. K., 1942, Methods of determining permeability of water-bearing materials with special reference to discharging-well methods: U.S. Geol. Survey Water-Supply Paper 887, 192 p.

Wilcox, L. U., 1955, Classification and use of irrigation waters: U.S. Dept. Agriculture Circ. 969, 19 p.

Wisler, C. O., and Brater, E. F., 1959, Hydrology: New York, John Wiley and Sons, Inc., 408 p.